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IBM 7090/7094 IBSYS Operating System
Version 13
Macro Assembly Program (MAP) Language

This publication provides detailed information for writing source programs in the 7090/7094 Macro Assembly Program (MAP) Language.

Users of the MAP symbolic programming language are provided with an extensive set of pseudo-operations, as well as all 7090/7094 machine operations.

The Macro Assembly Program (7090-SP-804), IBMAP, is a component of the 7090/7094 IBSYS Operating System: Version 13, IBJOB Processor and operates under the IBJOB Monitor.

Preface

The MAP language and its use in writing 7090/7094 programs are described in this publication. This symbolic language encompasses all 7090/7094 machine operations, extended machine operations, and special operations. In addition, MAP provides more than sixty pseudo-operations, including the powerful macro-facility, all of which are described in this publication.

MAP language programs are processed by the 7090/7094 assembly program, IBMAP, which is a component of the 7090/7094 IBJOB Processor and which operates under the IBJOB Monitor. The facilities of IOCS, FORTRAN, and COBOL are accessible to the MAP user.

To assist the user in making the most effective use of this flexible programming tool, basic information about the MAP language is provided in Part I of this publication. Its main features and capabilities are outlined, and the constituents of MAP symbolic instructions are explained.

The pseudo-operations provided by MAP have been divided into classes according to function. Most of the pseudo-operations are described in Part II, where their formats are shown and their use in programs is explained and demonstrated.

The macro-facility is described separately in Part III.

Five appendixes following Part III provide supplementary information related to the MAP language.

It has been assumed that the reader is familiar with the contents of one of the following publications:

IBM 7090 Principles of Operation, Form A22-6528
IBM 7094 Principles of Operation, Form A22-6703

The following related publications may also be useful, depending on individual interests and requirements:

IBM 7090/7094 IBSYS Operating System: Version 13, System Monitor (IBSYS), Form C28-6248
IBM 7090/7094 IBSYS Operating System: Version 13, IBJOB Processor, Form C28-6389
IBM 7090/7094 IBSYS Operating System: Version 13, Input/Output Control System, Form C28-6345
IBM 7090/7094 IBSYS Operating System: Version 13, FORTRAN IV Language, Form C28-6390
IBM 7090/7094 IBSYS Operating System: Version 13, COBOL Language, Form C28-6391

Machine requirements for MAP language programs are given in the publication *IBM 7090/7094 IBSYS Operating System: Version 13, IBJOB Processor*, Form C28-6389.

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Part I. Symbolic Programming Using MAP

Programmers can communicate instructions to computers at three general language levels. The language of the computer itself is the most basic. At the highest level are scientific and commercial programming languages, such as FORTRAN and COBOL, respectively. Assembly-program languages like the MAP (Macro Assembly Program) language are at the intermediate level.

Because the computer executes instructions at the machine-language level, a source program written at either of the other two levels must be reduced to a machine-language object program before it can be executed. Machine-language programming is theoretically the most efficient, since no translation from source program to object program is required. For the programmer, however, programming in machine language is tedious and time consuming, and programming errors are more likely.

A source program written in the FORTRAN language closely resembles the mathematical notation used to state a problem to be solved by traditional methods. The COBOL language is based on English statements much like those that would be used to explain a procedure. These languages are relatively easy to learn and to use because of their similarity to the ordinary languages of business and science.

Source programs written in these languages are translated into machine-language programs within the computer by a compiler program. By using a compiler, the computer can produce an efficient machine-language program from a FORTRAN or COBOL source program faster and more accurately than a programmer can. Such compiler languages thus offer marked advantages over machine-language programming. However, compiler languages are somewhat restrictive. Some programming features that are available when using machine language cannot be included in any present-day compiler.

An assembly-program language is similar in structure to machine language. However, mnemonic symbols are substituted for each binary instruction code, and symbols provided by the programmer are substituted for the other fields of an instruction. An assembly-program language can also provide additional advantages beyond machine-language programming. For example, pseudo-operations can be provided, which often permit the coding of one instruction instead of many instructions. Thus, an assembly program provides the programmer with all the flexibility and versatility of machine language but with greatly reduced programming effort. In addition, error checking can be included to facilitate source program debugging.

7090/7094 MAP Language Features

Operations

The 7090/7094 MAP (Macro Assembly Program) language can be used for all of the 7090/7094 machine operations, the extended machine operations, and the special machine operations. (All such operations recognized by MAP are listed in Appendix A with supplementary information about them.) In addition, the MAP language provides an extensive set of pseudo-operations that supplement machine instructions.

A pseudo-operation is any operation included in the MAP language that is not an actual machine operation, extended machine operation, or special machine operation. Pseudo-operations are used by the programmer in much the same way as machine operations. MAP provides more than sixty such pseudo-operations to meet a variety of programming needs. These pseudo-operations, which are described in detail in Parts II and III, have been divided into classes according to function.

Location-Counter Pseudo-Operations enable the programmer to establish symbolic location counters and control their operation.

Storage-Allocation Pseudo-Operations reserve areas of core storage.

Data-Generating Pseudo-Operations introduce data into a program in any of a variety of formats. They are also used in combination to generate tables of data.

Symbol-Defining Pseudo-Operations are used to assign specific values to symbols.

Boolean Pseudo-Operations define symbols as Boolean quantities.

Conditional-Assembly Pseudo-Operations base assembly of an instruction on programmer established criteria.

Symbol-Qualifying Pseudo-Operations qualify symbols within sections of a program.

Control-Section Pseudo-Operations delimit sections of a program, facilitating cross-referencing among programs and among program segments.

File-Description Pseudo-Operations define the requirements of input/output files used by the program.

Operation-Defining Pseudo-Operations define or redefine symbols as operation codes.

Miscellaneous Pseudo-Operations indicate the end of a program, extend the variable field of an operation, and permit remarks to be entered into the assembly listing.

Absolute-Assembly Pseudo-Operations specify the punched output format of an absolute assembly.

List-Control Pseudo-Operations specify the contents and format of an assembly listing.

Special Systems Pseudo-Operations generate subroutine calling sequences. They may also be used to save and restore the index registers and indicators.

Macro-Defining Pseudo-Operations are used to define programmer macro-operations. They are used in conjunction with the *macro-related pseudo-operations,* which extend the facilities of macro-operations.

Macro-Operations

The programmer macro-operation facility is a very flexible and powerful programming tool. Many programming applications involve a repetition of a pattern of instructions, often with parts of the instructions varied at each iteration. Using the macro-defining pseudo-operations, a programmer can define the pattern as a macro-operation.

In defining the pattern, the programmer gives it a name that becomes the operation code used to generate the pattern of instructions. Thus, the coding of a single instruction can cause the pattern of instructions to be repeated as often as desired. Moreover, parts of the instruction can be varied each time the sequencc is repcated. The contents of any field of any instruction within the pattern may be varied, and even entire instructions can be inserted in the sequence. The macro-operation facility is described in Part III.

Location Counters

During assembly, a location counter registers the next location to be assigned to an instruction. For most machine instructions processed by the assembly program, the contents of the location counter in effect at that time (the "current" location counter) is increased by 1. Some pseudo-operations may result in no increase, an increase of 1, or an increase of more than 1.

MAP enables a programmer to create and control as many symbolic location counters as he needs by using the location-counter pseudo-operations. Control can be transferred back and forth among them as often as desired.

This feature permits instructions coded in one sequence to be loaded in another, the establishment of constant tables, etc.

Absolute and Relocatable Assemblies

The control routines of the operating system occupy lower core storage. Therefore, a program may not be loaded into this area but must be loaded into the first unused machine location. However, the programmer need not know the address of this location, since the loader (IBLDR) can automatically relocate each program segment to be loaded.

The first address of a program segment to be executed is called the load address, and each succeeding instruction is loaded relative to that address. Thus, the address of an instruction at load time is the address assigned to it during assembly plus the load address of the program segment in which the instruction appears.

In a relocatable assembly, the assembly program produces an object deck that is automatically relocated at execution time by IBLDR. However, it may sometimes be desirable to load a program beginning at a certain fixed location in core storage. A program loaded in this way is said to have an absolute origin. The programmer specifies a certain location as the load address for that deck. (An absolute origin may also be specified within a relocatable assembly. See the section "Relocation Properties of Symbols.")

In absolute assemblies, output is in the standard 22-word-per-card format, which is specified on the $IBMAP control card and by the ABS pseudo-operation. Output in this format cannot be handled by IBLDR. Whether the assembly is absolute or relocatable is specified by the programmer on the $IBMAP card (see the publication *IBM 7090/7094 IBSYS Operating System: IBJOB Processor*, Form C28-6389.)

Error Checking

Source programs written in the MAP language are checked for a variety of errors, including format errors, table overflow errors, input/output errors, improper references, and incorrectly coded operations. In addition, the severity of the error is indicated.

In a normal assembly, messages are printed just after the assembly listing. All messages for a given card are printed together, and the card groups are printed in ascending sequence. Correlation with the listing is accomplished by printing the line number, which is assigned by the assembly program, in the left margin of the listing for each card that requires a message.

A list of MAP error messages and an explanation of the severity code used are included in the publication *IBM 7090/7094 IBSYS Operating System: IBJOB Processor*, Form C28-6389.

Forming Symbolic Instructions

Instruction Fields

In the MAP language, each symbolic instruction is punched on a separate standard IBM card. A single instruction may have as many as five parts, occupying five fields on the card.

THE NAME FIELD

An instruction may be given a symbolic name by the programmer, so that references may be made in other instructions to the named instruction. (Other methods are also available for referring from one instruction to another. For example, see the section "Relative Addressing.")

The use of a name is generally optional. However, some pseudo-operations do require a symbol in the name field. Name-field and other requirements of each of the pseudo-operations are explained in Parts II and III. Also, the specifications for symbols used in the name field are given in the section "Symbols."

The name given to a symbolic instruction is from 1 to 6 characters long, and it occupies columns 1 through 6 on the card.

THE OPERATION FIELD

The machine operation code, pseudo-operation code, programmer macro-operation code, or an operation code previously defined by one of the operation-defining pseudo-operations appears in the operation field.

The operation field is punched beginning in column 8. Column 7 separates the name field from the operational field. Column 7, which is usually left blank, is ignored by the assembly program.

The character asterisk (*) may be used immediately to the right of some operation codes to indicate indirect addressing. Those machine instructions that are indirectly addressable are indicated in Appendix A. If indirect addressing is specified for an instruction in which it is not permitted, the asterisk (*) is ignored and a low-severity error message is issued.

The operation field is usually restricted to a maximum of six characters. However, an operation code of six characters defined by one of the operation-defining pseudo-operations may be followed by an asterisk (*) to indicate indirect addressing.

THE VARIABLE FIELD

The variable field of a symbolic instruction may contain subfields, separated by commas.

In machine instructions, these subfields contain the address, tag, and/or decrement (or count) parts of instruction, depending on the requirements of the particular instruction. These parts of the variable field are supplied in the order: address, tag, decrement.

The subfields that are required, optional, or not permitted in the variable fields of all 7090/7094 machine instructions, extended machine operations, and special operations are indicated in Appendix A.

In pseudo-operations, the subfields of the variable field may contain symbols, symbolic expressions, and literals. The contents of the variable field specified for each of the MAP pseudo-operations is given in Parts II and III.

A null subfield is indicated as being present but as having no value. If a null subfield is at the beginning of the variable field, it is indicated by a single comma. If it is between two other subfields, it is expressed by two consecutive commas. A null subfield at the end of the variable field is represented by a single comma followed by a blank.

If a subfield that is not used in the variable field (an irrelevant subfield) is to be followed by a subfield that is required (a relevant subfield), the irrelevant subfield must be indicated. Irrelevant subfields at the end of the variable field may be indicated as null or may be omitted entirely. For example, the following pairs of instructions are equivalent:

```
TXH     0,0,1
TXH     ,,1
IORP    ALPHA,0,1
IORP    ALPHA,,1
CLA     ALPHA,0
CLA     ALPHA
TXH     ALPHA,0,0
TXH     ALPHA,,
PXA     0,0
PXA     ,
```

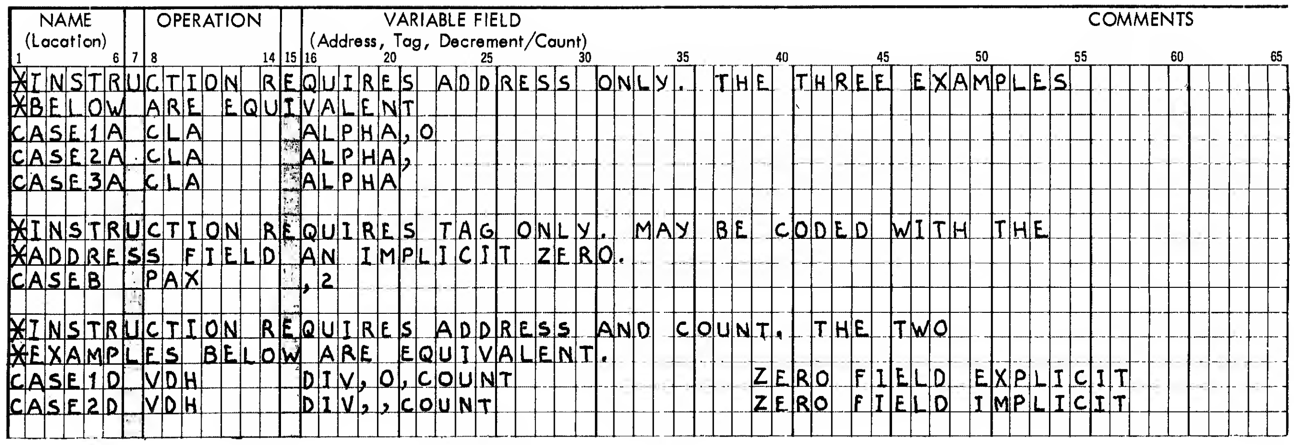
In the last two pairs, the commas may not be omitted, since the assembly program checks for a minimum number of subfields. The TXH instruction requires three subfields, while the PXA instruction requires two. These subfields are not irrelevant and must be included.

The variable field is separated from the operation field by at least one blank column. The variable field may begin in column 12 but may never begin after column 16. The variable field cannot extend beyond column 72. An instruction having a variable field extending into column 72 may not have a comments field. However, the variable field of most instructions may be extended over more than one card, each having its own comments field, by using the ETC pseudo-operation.

THE COMMENTS FIELD

The comments field is included for the convenience of the programmer and does not affect execution of the program. This field is generally used for explanatory remarks. (See also the section "The Asterisk (*) Remarks Cards.")

A blank precedes the comments field to separate it from the variable field. This field extends through column 72 on the card. If there is a blank variable field, the comments field may begin as soon as column 17. An example of the use of the comments field is shown in Figure 1.



```
NAME          OPERATION       VARIABLE FIELD                                              COMMENTS
(Location)                    (Address, Tag, Decrement/Count)
1     6 7 8          14 15 16   20   25   30   35   40   45   50   55   60   65
*INSTRUCTION REQUIRES ADDRESS ONLY. THE THREE EXAMPLES
*BELOW ARE EQUIVALENT
CASE1A  CLA            ALPHA,0
CASE2A  CLA            ALPHA,
CASE3A  CLA            ALPHA

*INSTRUCTION REQUIRES TAG ONLY. MAY BE CODED WITH THE
*ADDRESS FIELD AN IMPLICIT ZERO.
CASEB   PAX            ,2

*INSTRUCTION REQUIRES ADDRESS AND COUNT. THE TWO
*EXAMPLES BELOW ARE EQUIVALENT.
CASE1D  VDH            DIV,0,COUNT            ZERO FIELD EXPLICIT
CASE2D  VDH            DIV,,COUNT             ZERO FIELD IMPLICIT
```

Figure 1. Example of MAP Coding Shows Use of Comments Field

THE SEQUENCE FIELD

Symbolic instructions may be numbered for identification in the sequence field, which includes columns 73 through 80 on the card.

THE ASTERISK (*) REMARKS CARD

The remarks card is a special source card with an asterisk (*) in column 1 and any desired information in the rest of the card.

Any card with an asterisk in column 1 is treated by the assembly program as a remarks card, and its contents are printed out in the assembly listing. It has no other effect on the assembly.

Remarks cards may be grouped and may appear anywhere in a program except in macro-operations or between ETC cards. They are frequently used at the beginning of a program to state the problem to be solved, to describe the technique used, etc. (MAP also makes a remarks card available by using the pseudo-operation REM, which is described in the section "The REM Pseudo-Operation.")

Examples of remarks cards are shown in Figure 1, as well as methods of coding a variable field.

Symbols

The symbolic names used in the name and variable fields of symbolic instructions consist of one to six nonblank BCD characters (see Appendix E). At least one nonnumeric character must be included, but none of the following ten characters may be used:

+	(plus sign)	=	(equal sign)
−	(minus sign)	,	(comma)
*	(asterisk)	'	(apostrophe)
/	(slash)	(	(left parenthesis)
$	(dollar sign)	)	(right parenthesis)

Parentheses in a symbol cause a low-severity warning message to be printed, but assembly is not affected. However, the ( )OK option specified on the $IBMAP control card (see the publication *IBM 7090/7094 IBSYS Operating System: IBJOB Processor,* Form: C28-6389) indicates that parentheses in symbols are desired, and no message will be printed.

Examples of valid symbols are:

A	3.2XY
37B2	DECLOC
DELTA	

Conversely, the following are *not* valid symbols for the reasons indicated:

A+B	(invalid character)
3921	(no nonnumeric characters)
A2B4C6D	(more than six characters)

Defining Symbols

When a symbol has been assigned a value, it is said to be defined. The assigned value can be the address of a location within core storage, an arbitrary quantity specified by the programmer, or a dependent value assigned by the assembly program. Values are assigned to symbols during and after the first of the two passes made by the assembly program over the source program. Further information about the assembly program is provided in the publication *IBM 7090/7094 IBSYS Operating System: IBJOB Processor.* Form C28-6389.

Ordinary Symbols

Several types of symbols are used in the variable fields of machine instructions and in most of the pseudo-operations.

1. Location symbols are so called because of their appearance in the name field of an instruction. During the first pass of the assembly program, location symbols in the variable field of an instruction are immediately assigned a value called an S-value. The S-value is 1 if the symbol has previously appeared in the name field of an instruction and 0 if it has not. After the first pass has been completed, these symbols are assigned

the value of the address of the instruction in which they appeared as a name-field symbol.

Absolute symbols are location symbols having fixed values that are independent of any relocation of the program segment.

2. Virtual symbols are used in the variable field of an instruction and never appear in any name field. Virtual symbols, which have special functions in MAP, are defined at load time. The S-value is 0. (For further information, see the publication *IBM 7090/7094 IBSYS Operating System: IBJOB Processor*, Form C28-6389.) Virtual symbols are permitted only in a relocatable assembly. In an absolute assembly, virtual symbols are flagged as undefined.

3. System symbols from the IBSYS, IOEX and IBJOB communication regions are predefined by the assembler if a System Symbol Option (MONSYM or JOBSYM) appears on the $IBMAP control card. If symbols thus defined are used in the variable field of an instruction in the source program, they will be treated as absolute symbols appearing in the qualification section "S.S." The S-value is 1. (For further information concerning the use of the System Symbol options, and the symbols involved, see the publication, *IBM 7090/7094 IBSYS Operating System: IBJOB Processor*, Form C28-6389.)

Immediate Symbols

Immediate symbols are created by using them in the name field of the SET pseudo-operation. Immediate symbols are assigned a value (S-value) during the first pass of the assembly program. Immediate symbols may also be redefined throughout a program by using additional SET pseudo-operations. (See the section "The SET Pseudo-Operation.") The final value of an immediate symbol is used in evaluating variable fields of pseudo-operations affecting location counters.

Relocation Properties of Symbols

An absolute origin may be specified in a relocatable assembly, which should not be confused with an absolute assembly. If an absolute origin is given in a relocatable assembly, any symbols whose definitions depend on that origin are absolute. However, instructions under the absolute origin may refer to symbols elsewhere in the program. The assembly can be returned to the relocatable mode by subsequently specifying a relocatable origin.

Under the following conditions, symbols are absolute even if they appear within a relocatable assembly:

1. Symbols whose values depend on an absolute origin (as a result of using the ORG or BEGIN pseudo-operations).

2. Symbols defined by the BOOL, RBOOL, and LBOOL pseudo-operations.

3. Symbols defined by the EQU or SYN pseudo-operations and whose values reduce to a constant.

4. Symbols defined by a MAX or MIN pseudo-operation that yield a constant.

5. Symbols used in the variable field of type D instructions.

6. Symbols defined by the SET pseudo-operation.

Literals

Literals provide a simple means for introducing data words and constants into a program. For example, if a programmer wishes to add the number 1 to the contents of the accumulator, he must have the number 1 at some location in storage.

In contrast to other types of subfields, the contents of a literal subfield is itself the data to be operated on. The appearance of a literal directs the assembly program to prepare a constant equal in value to the content of the literal subfield. The assembly program replaces the subfield of the variable field of the instruction containing the literal with the address of the constant thus generated.

All the literals used in a program are placed in the Literal Pool. Unless the programmer specifies another location (see "Literal-Positioning Pseudo-Operations"), the Literal Pool begins one location beyond the final value of the location counter in use at the end of the program.

There are three types of literals — decimal, octal, and alphameric.

DECIMAL LITERALS

A decimal literal consists of the character = followed by a decimal data item. Three types of decimal data items are recognized by MAP:

Decimal Integers. A decimal integer is one or more of the digits 0 through 9, and it may be preceded by a plus or minus sign. Maximum size of the decimal integer is $2^{35} - 1$.

Floating-Point Numbers. A floating-point number has two components.

1. The *principal part* is a signed or unsigned decimal number, which may be written with or without a decimal point. The decimal point may appear at the beginning, at the end, or within the decimal number. If an exponent part is present, the decimal point may be omitted, in which case it is assumed to be at the right end of the decimal number. The principal part cannot exceed twenty digits. If it does, the number will be truncated and only the first twenty digits will be used.

2. The *exponent part* consists of the letters E or EE followed by a signed or unsigned decimal integer. (The letters EE indicate a double-precision floating-point number.) The exponent part may be omitted. If the exponent part is used, it must follow the principal

part. The exponent part cannot exceed two digits. If it does, it will be truncated and only the first two digits will be used.

A floating-point number is converted to a normalized floating-point binary word. The exponent part, if present, specifies a power of ten, by which the principal part is multiplied during conversion. For example, all of the following floating-point numbers are equivalent and are converted to the same floating-point binary number.

```
3.14159
31.4159E-1
314159.E-5
314159E-5
.314159E1
```

The octal representation of this number is

```
202622077174
```

Similarly, the number .314159EE1 is converted to a double-precision floating-point number. Its octal representation is

```
202622077174
147015606335
```

Fixed-Point Numbers. A fixed-point number has three components.

1. The *principal part* is a signed or unsigned decimal number, which may be written with or without a decimal point. The decimal point may appear at the beginning, at the end, or within the decimal number. If the decimal point is omitted, it is assumed to be at the right end of the decimal number. The principal part cannot exceed twenty digits. If it does, the number will be truncated and only the first twenty digits will be used.

2. The *exponent part* consists of the letters E or EE followed by a signed or unsigned decimal integer. (The letters EE indicate a double-precision fixed-point number.) The exponent part may be omitted. If the exponent part is used, it must follow the principal part. The exponent part cannot exceed two digits. If it does, it will be truncated and only the first two digits will be used.

3. The *binary-place part* consists of the letters B or BB followed by a signed or unsigned decimal integer. (The letters BB indicate a double-precision fixed-point number.) The binary-place part must be present in a fixed-point number and must come after the principal part. If the number has an exponent part, the binary-place part may either precede or follow the exponent part. The binary-place part may not exceed two digits. If it does, the number will be truncated and only the first two digits will be used.

A fixed-point number is converted to a fixed-point binary number that contains an understood binary point. The binary-place part specifies the location of this understood binary point within the word. The number that follows the letters B or BB specifies the number of binary places in the word at the left of the binary point. The sign bit is not counted. Thus, a binary-place part of zero specifies a 35-bit binary fraction. B2 specifies two integral places and 33 fractional places. B35 specifies a binary integer. B-2 specifies a binary point located two places to the left of the leftmost bit of the word; that is, the word would contain the low-order 35 bits of a 37-bit binary fraction. As with floating-point numbers, the exponent part, if present, specifies a power of ten, by which the principal part will be multiplied during conversion.

For example, the following fixed-point numbers all specify the same bit configuration, but not all of them specify the same location for the understood binary point:

```
22.5B5
11.25B4
1125E-2B4
9B7E1
```

All of the above fixed-point numbers are converted to the binary configuration having the octal representation

```
264000000000
```

The following double-precision fixed-point numbers

```
10BB35
1B35EE1
1BB35E1
1BB35EE1
```

are converted to the binary configuration having the octal representation

```
000000000012
000000000000
```

Double-precision literals are stored in consecutive locations. The first or high-order part is automatically stored in an even location relative to the beginning of the Literal Pool. If these literals are to be used as operands in double-precision operations (7094), an EVEN pseudo-operation must be inserted immediately before the LORG pseudo-operation if there is one; otherwise it must be inserted before the END pseudo-operation.

OCTAL LITERALS

An *octal literal* consists of the two characters =O followed by an octal integer.

An *octal integer* is a string of not more than twelve of the digits 0 through 7, and it may be preceded by a plus or minus sign.

Examples of octal literals are:

```
=O123      000000000123
=O+123     000000000123
=O-123     400000000123
```

ALPHAMERIC LITERALS

An *alphameric literal* consists of the two characters =H followed by exactly six alphameric characters.

The six characters following the H are treated as data even if one or more of them is a comma or a blank.

Examples of alphameric literals are:

```
=H12ABCD
=HTADbbb, where b represents a blank
```

Writing Expressions

The programmer writes expressions to represent the subfields of the variable field of symbolic instructions. Expressions are also used in the variable fields of many of the pseudo-operations in accordance with the rules set forth for each specific case.

Expressions are comprised of elements, terms, and operators.

ELEMENTS

An element is the smallest component of an expression and is either a single symbol or a single integer less than 2^{15}. The asterisk (*) may be used as an element representing the location of the instruction in which it appears.

Examples of valid elements are:

```
A
427
ALPHA
```

TERMS

A term is a group of one or more elements and the operators * (indicating multiplication) and / (indicating division).

A term consists of one or more elements, with each element separated by an operator. A term must begin and end with an element. Two operators or two elements in succession are never permissible.

Examples of valid terms are:

```
A        A*B
427      C/1409
ALPHA    BETA*GAMMA/DELTA
```

There is no ambiguity between using the asterisk as an element and its use to denote multiplication, since position always makes clear its intended function. For example, a field coded

```
**B
```

would be interpreted as "the location of this instruction multiplied by B." Since a term must begin with an element, the first asterisk must be an element. The second asterisk must be an operator, which is required between two elements.

EXPRESSIONS

An expression is a group composed of one or more terms and the operators + (signifying addition) and − (signifying subtraction).

An expression consists of one or more terms, with each term separated by a plus or minus sign. An expression may begin with a plus or minus sign. Examples of valid expressions are:

```
A
ALPHA
ALPHA*BETA
-A/B
A*B-C/D+E*2303
*-A+B*C
```

The asterisk in the last example is used first as an element and then as an operator.

Evaluating Expressions

In evaluating expressions, elements are evaluated first, then individual terms, and finally the complete expression. The following procedure is used in evaluating expressions:

1. Each element is replaced with its numeric value.

2. Each term is evaluated by performing the indicated multiplications and divisions from left to right. In division, the integral part of the quotient is retained and any remainder is discarded immediately. For example, the value of the term 5/2*2 is 4.

In evaluating a term, division by zero is the same as division by one and results in the original dividend. Division by zero is not regarded as an error.

3. Terms are combined from left to right in the order in which they occur, with all intermediate results retained as 35-bit signed numbers.

4. Two operators or two elements in succession are meaningless. However, if two operators are coded in succession, the term or expression is evaluated as if a zero were the element separating the operators. An expression containing a leading or terminating operator is evaluated as if a zero preceded or followed the operator.

5. Finally, if the result is negative, it is complemented; in either case, the rightmost 20 bits are retained if the expression is a subfield of a VFD pseudo-operation. Otherwise, only the rightmost 15 bits are retained.

Grouping of terms by parentheses or any other means is not permitted. However, a product such as A(B-C) can be written simply A*B-A*C.

The expression ** may be used to designate a field the value of which is to be computed and inserted by the program. It is an absolute expression having a value of zero (the location of this instruction multiplied by zero).

Rules for Forming Expressions

The use of expressions is sometimes affected by whether elements within the expression are relocatable, absolute, or a combination of both.

In a relocatable assembly, an expression that contains more than one symbol is generally complex. An expression that includes a control-section name is also symbols (such as MAX and MIN), the variable field must be evaluated before load time. For further information, see the publication *IBM 7090/7094 IBSYS Operating System: IBJOB Processor*, Form C28-6389. The rules that must be followed in using expressions are provided in the discussions of the pseudo-operations.

Boolean Expressions

A Boolean expression is evaluated as an 18-bit Boolean quantity, unlike the 15-bit integer that normally results from the evaluation of an expression. Elements within a Boolean expression must be constant. All integers are specified as octal integers. An expression is Boolean if:

1. It appears in the variable field of a Boolean pseudo-operation (BOOL, RBOOL, LBOOL; see the section "Boolean Pseudo-Operations");
2. It appears as an octal subfield of a VFD pseudo-operation (see the section "The VFD Pseudo-Operation"); or
3. It forms the variable field of a Type D or extended Type D machine instruction (see Appendix A).

Relocatable symbols in a Boolean expression are evaluated as 15-bit integers and virtual symbols are evaluated as zero. In either case, an error message is issued.

In a Boolean expression, the four operators (+, −, *, /) have Boolean rather than arithmetic meanings, as shown in the table.

OPERATOR	MEANING	DEFINITION
+	"inclusive or" (also, "union")	0+0=0 0+1=1 1+0=1 1+1=1
−	"exclusive or" (also, "symmetric difference")	0−0=0 0−1=1 1−0=1 1−1=0
*	"and" (also, "intersection")	0*0=0 0*1=0 1*0=0 1*1=1
/	"complement" (also, "not" or "ones' complement")	/0=1 /1=0

The four Boolean operations are defined in the table for 1-bit quantities. The operation is extended to 18-bit quantities by handling each bit position independently.

The following conventions also apply in using Boolean expressions:

The / is a unary or one-term operator. The expression A/B means /B, and the A is ignored. However, the presence of the A is not regarded as an error by the assembly program. The definitions of / in this case are:

```
0/0=1
0/1=0
1/0=1
1/1=0
```

If the other operators (+, −, *) are used as unary operators, the definitions are as follows:

```
+A=A+=A
−A=0−A,A−=A−0
*A=error, A*=A*0=0
```

For the special case of the slash, the definition is:

```
A/=A/0=1
```

In expressions where both terms are missing, definitions are as follows:

```
+=0+0=000000
−=0−0=000000
*=Location counter
/=0/0=777777
```

In evaluating a Boolean expression, all integers are treated as 18-bit quantities. The operation / is performed first, followed by *, then by + and −.

The operators +, −, and * may immediately precede the slash in a Boolean expression. For example,

```
A−/B
```

is a valid Boolean expression. However, in no other case are two operators or two elements in succession permitted.

Using Symbols in Expressions

In MAP, ordinary symbols are not assigned values until a pass over the entire program has been completed. Therefore, there are no restrictions in the order of symbol definition. For example,

```
            ORG      A
A           EQU      10000
```

is a valid sequence in IBMAP.

Symbols in the variable field of pseudo-operations that affect location counters must be definable at assembly time. In the sequence

```
            BEGIN    ,A
            BSS      B
            BES      C
```

A, B, and C may not be virtual symbols. (The ORG pseudo-operation is not subject to this restriction.) The values of symbols B and C are always treated as constant.

In general, any valid expression may appear in the variable field of machine instructions. In a relocatable assembly, final evaluation of complex arithmetic expressions containing virtual symbols actually takes place at load time, when all symbols have been defined.

Relative Addressing

After an instruction has been named by the presence of a symbol in the name field, references to that instruction can be made in other instructions by using the symbol. Instructions preceding or following the named instruction can also be referenced by indicating their position relative to the named instruction. This procedure is called relative addressing. A relative

Relative Addressing

After an instruction has been named by the presence of a symbol in the name field, references to that instruction can be made in other instructions by using the symbol. Instructions preceding or following the named instruction can also be referenced by indicating their position relative to the named instruction. This procedure is called relative addressing. A relative address is, effectively, a type of expression. For example, in the sequence

```
ALPHA     TRA     BETA
          CLA     GAMMA
          SUB     DELTA
STGAM     STO     GAMMA
          TPL     LOCI
```

control may be transferred to the instruction CLA GAMMA by either of the following instructions:

```
          TRA     ALPHA+1
          TRA     STGAM-2
```

It is also possible to use the asterisk (*) as an element in a relative address. For example, in the sequence

```
          AXT     10,1
LOOP      CLA     A,1
          SUB     B,1
          SUB     C,1
          STO     SUM,1
          TIX     LOOP,1,1
```

the last instruction indicates a conditional transfer to location LOOP. This could also be written

```
          TIX     *-4,1,1
```

The address *−4 is interpreted as "the location of this instruction minus 4."

Relative addressing must be used carefully in combination with pseudo-operations, since some pseudo-operations may generate more than one word or no words in the object program. For example, the instruction

```
ALPHA     OCT     2732,427,12716
```

generates three words of octal data, with ALPHA assigned to the address of the first word generated. Thus the address ALPHA+2 refers to the third word generated (12716).

Reference can also be made to a word in a block of storage reserved by a BSS or BES pseudo-operation by using relative addressing. For example, the instruction

```
BETA      BSS     50
```

reserves a block of 50 words, where BETA is assigned to the first word of the block. The address BETA+1 refers to the second word, and BETA+*n* refers to the *(n+1)*st word.

Part II. MAP Pseudo-Operations

MAP provides the programmer with more than sixty pseudo-operations that can perform a variety of programming functions with greatly reduced programming effort. They have been grouped according to function, and the structure and purpose of most of the MAP pseudo-operations are described in this part of the publication. The macro-operation facility is covered separately in Part III.

Location-Counter Pseudo-Operations

Location counters enable instructions that are written in one sequence to be loaded in a different sequence. MAP enables a programmer to establish an indefinite number of location counters, which can be represented by symbols of his choice. The symbol used to represent a location counter may duplicate any other symbol in the program except another location-counter symbol.

The blank location counter, so called because it has no associated symbol, is the basic location counter. If the USE pseudo-operation is not used, instructions are assembled under the blank location counter. In addition, a location counter represented by two slashes (//) is reserved for use with blank COMMON.

The USE Pseudo-Operation

The USE pseudo-operation places succeeding instructions under control of the location counter represented by the symbol in the variable field. The format of the USE pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	USE	Either: 1. A single symbol, or 2. Blanks, or 3. //, or 4. The word PREVIOUS

The location counter in control at the time of the USE pseudo-operation is suspended at its current value. It is temporarily preserved as the "previous" counter. It continues from this value if it is reactivated by another USE. If USE with the word PREVIOUS in the variable field is coded, the previous location counter is reactivated. For example, the effect of the sequence

```
USE     A
USE     B
USE     PREVIOUS
```

is identical to that of

```
USE     A
USE     B
USE     A
```

This option provides a means of returning to a location counter even if the counter symbol is not known.

A USE pseudo-operation with a blank variable field must precede the first instruction of the deck if the blank counter is set to a value other than zero by the operation

```
BEGIN     ,expression
```

The sequence of location counters is: the blank counter first, the other symbolic counters in the order of their first appearance in a USE or BEGIN pseudo-operation, and finally the // counter.

The BEGIN Pseudo-Operation

The BEGIN pseudo-operation specifies a location counter and establishes its initial value. The format of the BEGIN pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	BEGIN	Two subfields, separated by a comma: 1. A location counter symbol, 2. Any expression

The expression in the variable field may contain any symbol or constant. Relocatable symbols are given their assembly value, and this value becomes absolute. Control-section symbols are given a value of zero.

The value of the second subfield of the variable field is used as the initial value for the location counter represented by the symbol in the first subfield. For example, the instruction

```
BEGIN     ALPHA,BETA
```

would cause the instructions following

```
USE       ALPHA
```

to be assembled beginning at location BETA.

If no BEGIN is given for the blank location counter, its initial value is defined as 0 (absolute 0 in an absolute assembly and relative 0 in a relocatable assembly). If no BEGIN is given for the *n*th location counter (taken in location counter order), its initial value is given as the last value by the $(n-1)$st location counter. If more than one BEGIN is given for a specific location counter, only the first one is used. Each of the others causes an error message to be issued and is printed as a comment, but is otherwise ignored.

A BEGIN may appear anywhere in the program regardless of the location counter in control.

Note that if the blank location counter is set to a value other than zero by the operation

```
BEGIN    ,expression
```

the USE pseudo-operation with a blank variable field must precede the first instruction of the deck.

The order in which location counters are used is illustrated in the example:

```
instruction  1
BEGIN        A,*
USE          A
instruction  2
instruction  3
BEGIN        C,*
instruction  4
instruction  5
USE          //
instruction  6
instruction  7
USE          B
instruction  8
instruction  9
USE          C
instruction  10
END
```

In this sequence, instruction counters are used in the order: blank, A, C, B, and //. At load time, the sequence of instructions will be:

```
instruction  1
instruction  2
instruction  3
instruction  10  (instruction 4 will be
                 overlaid)
instruction  8   (instruction 5 will be
                 overlaid)
instruction  9
instruction  6
instruction  7
```

The ORG Pseudo-Operation

The ORG (Origin) pseudo-operation redefines the value of the current location counter. The format of the ORG pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	ORG	Any expression

The ORG pseudo-operation causes the current location counter to be reset to the value of the variable field. If there is a symbol in the name field, it is given this value.

A virtual symbol may not appear in the variable field of an ORG pseudo-operation unless the symbol has been previously defined in another deck in the same job segment.

Absolute origins are permitted in a relocatable assembly. An origin is treated as absolute if the value of the variable field of the ORG pseudo-operation is constant. Thus,

```
ORG      5000
```

sets the location counter to 5000. In a relocatable assembly, references to symbols under the control of an absolute origin (ORG or BEGIN) are absolute.

For example, the location counter is set at the sixth location of the program by

```
ORG      START+5
```

where START is the first location of the program.

An ORG terminates the effect of a LOC pseudo-operation by redefining the value of the current location counter and ensuring that this value is used as the next binary card origin.

The LOC Pseudo-Operation

The LOC pseudo-operation permits symbolic addressing in segments of an object program that are to be loaded at one area of storage and then moved to, and executed from, another. It redefines the value of the current location counter but does not affect the load address.

The format of the LOC pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	LOC	Any expression

The current location counter is reset to the value specified in the variable field. If there is a symbol in the name field, it is given this value.

However, binary card origins are not affected by the LOC pseudo-operation. They remain relative to the value of the location counter prior to the LOC, indicating the address at which the program segment is to be loaded.

If another LOC is encountered when one is already in effect, the current location counter is set to the value specified in the new LOC.

The LOC pseudo-operation may be used only if an absolute assembly (ABSMOD) is specified on the $IBMAP control card. (See the publication *IBM 7090/7094 IBSYS Operating System: IBJOB Processor*, Form C28-6389, for a discussion of the $IBMAP control card.)

The effect of a LOC pseudo-operation must be terminated (see "The ORG Pseudo-Operation.") before a USE pseudo-operation appears. Otherwise, the LOC will be terminated automatically and an error message issued because undesirable location counter values may result.

Storage-Allocation Pseudo-Operations

The storage-allocation pseudo-operations reserve core storage areas within the sequence of the program.

The BSS Pseudo-Operation

The BSS (Block Started by Symbol) pseudo-operation reserves a block of consecutive storage locations and may describe the data that will occupy the block. The format of the BSS pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	BSS	One or two subfields, separated by a comma: 1. Any expression, 2. Modal and dimensional information

The BSS pseudo-operation increases the value of the current location counter by the defined value of the expression in the first subfield of the variable field. The expression may contain any symbol or constant. Relocatable symbols are given their assembly value, and this value becomes absolute. Control-section symbols are given a value of zero. If there is a symbol in the name field, its defined value is that of the location counter just before the increase.

When the second subfield is used, a symbol must appear in the name field. This subfield supplies modal and dimensional information to the debugging dictionary about the data that will occupy the block. The second subfield must be used if the symbol in the name field also appears in the variable field of a KEEP pseudo-operation or if the full debugging dictionary is specified in the variable field of a $IBMAP card. (See the publications *IBM 7090/7094 IBSYS Operating System: IBJOB Processor Debugging Package,* Form C28-6393 and *IBM 7090/7094 IBSYS Operating System: IBJOB Processor,* Form C28-6389.) The format for this subfield is:

mode (d_1, d_2, d_3)

where d_1, d_2, and d_3 are the dimensions, if any, of the array denoted by the symbol in the name field, and mode is one of the following:

O	Octal
F	Floating-point number
X	Fixed-point number
D	Double-precision floating-point number
J	Complex number
L	Logical
S	Symbolic instruction
C	Symbolic command
H	Alphameric

If an entry for mode is not one of the nine recognized letters above, the mode is assumed to be octal. If an entry for dimension is not a decimal integer, an error message is issued.

When the second subfield is not used, it is assumed that the mode is octal and the dimension is 1.

For example, in the sequence

```
ALPHA       IORT      BETA,,4
BETA        BSS       4
GAMMA       IORT      DELTA,,6
```

if ALPHA has been assigned to location 1001, BETA will be assigned to location 1002 and GAMMA to location 1006. Thus, four locations are reserved for an array whose first element is at location BETA; and an entry, specifying that this array is one-dimensional and that its elements are octal numbers, is made into the debugging dictionary.

In addition to reserving four locations, the instruction

```
BETA        BSS       4,F(2,2)
```

indicates to the debugging dictionary that the data to occupy this area is a 2 by 2 array of floating-point numbers.

The area reserved by the BSS pseudo-operation is not zeroed.

The BES Pseudo-Operation

The BES (Block Ended by Symbol) pseudo-operation also reserves a block of consecutive storage locations and may describe the data that will occupy the block. The format of the BES pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	BES	One or two subfields, separated by a comma: 1. Any expression, 2. Modal information

The expression in the first subfield of the variable field may contain any symbol or constant. Relocatable symbols are given their assembly value, and this value becomes absolute. Control-section symbols are given a value of zero.

The BES pseudo-operation functions almost identically to a BSS pseudo-operation except that the symbol in the name field is defined after the location counter increases and thus refers to the first word following the reserved block.

A symbol must appear in the name field of a BES pseudo-operation if the second subfield of the variable field is used. This subfield has the same use as it does in the BSS except that it specifies modal information only. (If dimensional information is given, it is ignored.) Thus an entry in the second subfield of the variable field of a BES instruction consists of one of the letters O, F, X, D, J, L, S, C, or H, as described in the discussion of the BSS pseudo-operation. If the entry for mode is omitted or is a symbol other than the nine listed above, the mode is assumed to be octal.

For example, in the sequence

```
ALPHA       IORT      BETA,,4
BETA        BES       4
GAMMA       IORT      DELTA,,4
```

if ALPHA has been assigned to location 1001, both BETA and GAMMA will be assigned to location 1006 and four locations will be reserved for octal data.

In addition to reserving four locations, the instruction

```
BETA        BES      4,X
```

supplies the debugging dictionary with the information that the data to occupy this area is in the fixed-point mode.

The difference between BES and BSS can be seen in the sequence of instructions

```
ALPHA       BES      25
            CLA      BETA
```

which is effectively the same as

```
            BSS      25
ALPHA       CLA      BETA
```

The area reserved by the BES pseudo-operation is not zeroed.

The EVEN Pseudo-Operation

The EVEN pseudo-operation forces the current location counter to an even value to ensure an even address for the next instruction or data—usually a double-precision floating-point number. It is used only in the 7094 and has no effect in the 7090 or 7094 II. The format of the EVEN pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	EVEN	Ignored

In a 7094 relocatable assembly, the EVEN pseudo-operation causes the instruction

```
            AXT      0,0
```

to be inserted at load time if the load address of the AXT instruction is not even. The AXT instruction has no other effect on the program.

In a 7094 absolute assembly, the EVEN pseudo-operation causes the insertion of the instruction

```
            AXT      0,0
```

at assembly time so that it is available at load time in the event that the AXT instruction load address is not even. The AXT instruction has no other effect on the program.

The LDIR Pseudo-Operation

The LDIR (Linkage Director) pseudo-operation places the Linkage Director in the program at the point of the LDIR. The format of the LDIR pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	LDIR	Ignored

The Linkage Director is a unique location for each assembly, which is one beyond the final value of the location counter if the LDIR pseudo-operation is not used. If the LDIR pseudo-operation is used with a symbol in the name field, the programmer may refer to the Linkage Director.

The Linkage Director serves as a cross-reference for the CALL and SAVE pseudo-operations. If neither the LDIR nor LORG pseudo-operations is used, the Linkage Director precedes the Literal Pool. If the LDIR pseudo-operation appears more than once, only its first appearance is effective.

For example,

```
ALPHA       LDIR
```

would cause

```
ALPHA       PZE
            BCI      1,deckname
```

to be generated. The second subfield in the BCI operation is the deckname specified on the $IBMAP card (see the publication *IBM 7090/7094 IBSYS Operating System: IBJOB Processor*, Form C28-6389).

The COMMON Pseudo-Operation

The COMMON pseudo-operation has been preserved solely for compatibility with existing programs. When used together with the pseudo-operation

```
            CONTRL //
```

it reserves a storage area called blank COMMON for use with such programs. The format of the COMMON pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	COMMON	One or two subfields separated by a comma: 1. Any expression 2. Modal and dimensional information

The first subfield of the variable field may contain any symbol or constant. Relocatable symbols are given their assembly value, and this value becomes absolute. Control-section symbols are given a value of zero.

The COMMON operation causes:

1. Location counter // to be activated
2. A symbol in the name field, if any, to be defined as having the current value of location counter //
3. Location counter // to be increased by the defined value of the variable field expression
4. The location counter in use prior to the COMMON operation to be reactivated

The effect of the sequence

```
A           COMMON   E
```

is equivalent to

```
            USE      //
A           BSS      E
            USE      PREVIOUS
```

The second subfield of the variable field is used in the same way as the second subfield of the BSS pseudo-operation. (See "BSS Pseudo-Operation.")

Literal-Positioning Pseudo-Operations

Two pseudo-operations, LORG and LITORG, enable the programmer to determine the origin of the Literal Pool (see "Literals").

If neither of these pseudo-operations is used, the Literal Pool begins one location beyond the final value of the location counter in use at the end of a program. If more than one location counter is used by a program, the Literal Pool might overlay part of the program. For example, in the sequence

```
         USE     Y
A        BSS     1
         USE     X
B        CLA     = 1
         USE     Y
         END
```

the Literal Pool would begin at symbolic location B (one beyond the final value of location counter Y). Overlay also occurs if the // location counter is used but is not in effect at the end of the program. Specifying the location of the Literal Pool with a LORG or a LITORG can eliminate this overlapping.

If double-precision literals are used in a 7094 program, an EVEN pseudo-operation should precede a LORG or LITORG to ensure their entry at an even numbered address.

The LORG Pseudo-Operation

The LORG (Literal Pool Origin) pseudo-operation controls the positioning of all literals used in a program that are not under control of a LITORG pseudo-operation. The format of the LORG pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	LORG	Ignored

As a result of this pseudo-operation, the Literal Pool starts at the location of the LORG in the symbolic deck. This location is assigned the value of the symbol in the name field. For example, the sequence

```
         USE     Y
A        BSS     1
         USE     X
B        CLA     =1
         USE     Y
C        LORG
         END
```

would place the beginning of the literal pool one beyond symbolic location B and give it the symbolic name C.

If more than one LORG is given, only the first is effective. Duplicate literals under the control of a LORG are eliminated.

The LITORG Pseudo-Operation

The LITORG (Literal Origin) pseudo-operation enables literals used within a block of coding to be associated with that block. The primary use of this pseudo-operation is to associate the literals used within a control section (see "Control Dictionary Pseudo-Operations") with that control section.

The format of the LITORG pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	LITORG	Ignored

All literals encountered prior to a LITORG pseudo-operation (either from the beginning of the program or from a previous LITORG) are placed in a pool starting at the location of the LITORG. The beginning of the pool is assigned the symbol in the name field. For example, the sequence

```
         USE     X
         CLA     =1
         ADD     =2
A        LITORG
         USE     Y
         CLA     =3
         ADD     =4
B        LITORG
         USE     X
         END
```

would begin the first Literal Pool (containing 1 and 2) at symbolic location A and the second Literal Pool (containing 3 and 4) at symbolic location B.

Any literals encountered following a LITORG are positioned at the next LITORG or, if there is none, under the control of a LORG pseudo-operation. If there is neither a LORG nor another LITORG, subsequent literals follow an *LORG generated immediately preceding the END card.

Under LITORG control, duplicate literals are eliminated within each LITORG section.

Data-Generating Pseudo-Operations

Five pseudo-operations (OCT, DEC, BCI, LIT, and VFD) provide the programmer with a convenient means of introducing data expressed in a variety of forms into a program during assembly. Numbers introduced by these operations are often referred to as constants. A sixth pseudo-operation, DUP, permits a sequence of symbolic cards to be duplicated a specified number of times.

The OCT Pseudo-Operation

The OCT (Octal Data) pseudo-operation introduces binary data expressed in octal form into a program. The format of the OCT pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	OCT	1. One or more octal integers, separated by commas, or 2. Blanks

Each subfield in the variable field contains a signed or an unsigned octal integer of n digits, where $n \leqq 12$. The only limit on the number of subfields is that they must all be contained in the variable field of one card.

A blank variable field results in a word of all zeros.

The OCT operation converts each subfield to a binary word. These words are assigned to successively higher storage locations as the variable field is processed from left to right. If a symbol is used in the name field, it is assigned to the first word of data generated.

For example, each of the instructions

```
ALPHA       OCT       777777777777
ALPHA       OCT       -777777777777
ALPHA       OCT       -377777777777
```

would result in a binary word of 36 consecutive ones at location ALPHA.

In the instruction,

```
ALPHA       OCT       43,25,64
```

the binary equivalent of octal number 43 would appear at location ALPHA, the binary equivalent of 25 at location ALPHA+1, and the binary equivalent of 64 at ALPHA+2.

The DEC Pseudo-Operation

The DEC (Decimal Data) pseudo-operation introduces data expressed as decimal numbers into a program. The format of the DEC pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	DEC	1. One or more decimal data items, separated by commas, or 2. Blanks

The only limit on the number of subfields is that they must all be contained in the variable field of one card.

A blank variable field results in a word of all zeros.

The DEC operation converts each subfield to one or two binary words, depending on whether the decimal data item is single or double precision. These words are stored in successively higher storage locations as the variable field is processed from left to right. A symbol used in the name field is assigned to the first word of data generated.

For example, the instruction

```
ALPHA       DEC       43,25
```

would result in the binary equivalent of decimal number 43 appearing at location ALPHA and of decimal number 25 appearing at location ALPHA+1.

The BCI Pseudo-Operation

The BCI (Binary Coded Information) pseudo-operation introduces binary-coded decimal data into a program. Each data word generated consists of six 6-bit characters in standard BCD code. The format of the BCI pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	BCI	Two subfields, separated by a comma: 1. Single-digit count or symbol, 2. Alphameric data

If a digit is used in the count subfield, it must be a single digit from 1 through 9.

A null subfield indicates a count of ten. To accommodate the full ten words of data on the card, the null subfield must be indicated by a comma in column 12.

The data subfield contains any desired alphameric information (see Appendix E for the MAP BCD character code).

The length of the data subfield is determined by the number of six-character words specified in the count subfield. The immediate value of the symbol used in this subfield may also be used to determine the length of the data subfield.

The comments field begins immediately after the end of the data subfield, and no blank character is needed to separate the data subfield from the comments field. Any part of the data extending beyond the limit of the data field is treated as comments. Blanks are inserted as required to fill the data subfield to the length specified by the count subfield.

Thus, the BCI pseudo-operation introduces data words into consecutive locations, the number of words generated being equal to the number in the count subfield. A symbol used in the name field is assigned to the first word of data generated.

For example,

```
ALPHA       BCI       2,bPROFITbRISEbINbPER-
                      CENT
```

would generate the data words PROFIT RISE, whereas IN PERCENT would be comments.

The VFD Pseudo-Operation

Each VFD pseudo-operation generates no, one, or more than one binary data words and assigns them to successively higher storage locations. The format of the VFD (Variable Field Definition) pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	VFD	Any number of subfields, separated by commas

Each subfield of the variable field generates zero, one, or more than one bits of data. Thus, the unit of information for this pseudo-operation is the single bit.

Each subfield may be any one of three types: octal (Boolean), alphameric, or symbolic (including decimal integers).

The subfield of the VFD pseudo-operation consists of:

1. The type letter
   a. The letter O signifies an octal (Boolean) field.
   b. The letter H signifies an alphameric field.
   c. The absence of either O or H signifies a symbolic or decimal field.

2. The bit count — either a decimal integer or an immediate symbol specifies the number of bits to be generated by the subfield. If an immediate symbol is used, care should be taken to avoid confusion caused by the type letter. The maximum allowable bit count for a single subfield is 864.

3. The separation character slash (/)

4. The data item
   a. In an octal subfield, the data item may be a Boolean expression or an octal number.
   b. In an alphameric subfield, the data item is a string of characters none of which is a comma or a blank.
   c. In a symbolic subfield, the data item is one expression. The item is taken modulo 2^{20}.

Any number of subfields may be used. Successive subfields of the variable field are converted and packed to the left to form generated data words. If *n* is the bit count of the first subfield, the data item in that subfield is converted to an *n*-bit binary number that is placed in the leftmost *n* positions of the first data word to be generated. If *n* exceeds 36, the leftmost 36 bits of the converted data item form the first generated data word and the remaining bits are placed in the first $(n-36)$ bit positions of the second generated data word.

Each succeeding subfield is converted and placed in the leftmost bit positions remaining after the preceding subfield has been processed. If the total number of bit positions used is not a multiple of 36, the unused bit positions at the right of the last generated data word are filled with zeros.

If the data item is a single signed octal integer of any length, the sign is recorded as the high-order bit of the specified bit group.

If after conversion a symbolic or octal item occupies more than *n* bits, only the rightmost *n* bits of the converted data item are used. If the converted data item occupies fewer than *n* bits, enough zero bits are placed at the left of the converted data item to form an *n*-bit binary number. Neither condition is regarded as an error by the assembly program.

The data item in a symbolic subfield is converted as a symbolic expression. Decimal integers must not exceed 32767.

The data item in an octal subfield may be any valid Boolean expression. In addition, a signed or unsigned octal integer, which may exceed 18 bits, will be recognized and accepted by the assembly program.

The data item in an alphameric subfield may consist of any combination of characters other than a comma or a blank. Each character is converted to its 6-bit binary code equivalent. If the converted data item occupies more than *n* bits, only the rightmost *n* bits are used. If the converted data item occupies fewer than *n* bits, sufficient 6-bit groups of the form 110000 (the BCD code for blank) are placed at the left of the converted data item to form an *n*-bit binary number. If *n* is not a multiple of 6, the leftmost character or blank is truncated. None of these conditions is regarded as an assembly error.

For example, the VFD pseudo-operation could be used to break up a 36-bit word as follows: Positions S and 1 through 9 must contain the binary equivalent of the decimal integer 895, positions 10 through 14 must contain the binary equivalent of the octal integer 37, positions 15 through 20 must contain the binary equivalent of the character C, and positions 21 through 35 must contain the value of the symbol ALPHA. The instruction to generate this word is

```
VFD     10/895,O5/37,H6/C, 15/ALPHA
```

The LIT Pseudo-Operation

The LIT (Literal) pseudo-operation places data items from the subfields of the variable field into the Literal Pool in successively higher storage locations.

The format of the LIT pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	LIT	Data subfields, separated by commas

Rules for the contents of the data subfields are the same as those governing literals except that the equal sign (=) is omitted.

A Literal Pool entry made using a LIT pseudo-operation is assumed to be double precision if the variable field generates only two consecutive words of data. If a double-precision entry is made in the Literal Pool by either a LIT pseudo-operation or a double-precision literal, the number is placed in an even location relative to the beginning of the Literal Pool. (In this respect, the assembly program does not distinguish double-precision floating-point numbers from double-precision fixed-point numbers.)

For example,

```
        LIT     1,2
```

causes the number 1 to be placed in an even location relative to the beginning of the Literal Pool (which can result in duplicate entries in the Literal Pool).

The instruction

```
        LIT     1EE1
```

results in a double-precision entry beginning in an even location in the Literal Pool, but the instruction

```
        LIT     1EE1,2
```

results in a three-word entry with the first word not necessarily entered into an even location.

Thus, double-precision floating-point numbers may be used as constants if an EVEN pseudo-operation is used immediately preceding the LORG operation or, if no LORG is present, immediately before the END pseudo-operation.

The DUP Pseudo-Operation

The DUP (Duplicate) pseudo-operation causes an instruction or sequence of instructions to be duplicated. An important application is in generating tables. The format of the DUP pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	DUP	Two subfields, separated by a comma: 1. An expression 2. An expression

The first subfield represents instruction count, and the second subfield represents iteration count. Integers are generally used in these subfields. Symbols in the instruction count and iteration count subfields are evaluated for their S-values.

If *m* represents instruction count and *n* represents iteration count, the DUP pseudo-operation has the effect of duplicating the next *m* instructions *n* times.

The group of *m* instructions following the DUP establish the range of the DUP. The effect of the DUP pseudo-operation is that the set of *m* symbolic cards making up the range is copied *n*−1 times and placed in the symbolic deck behind the original set. (The name field of the symbolic card is duplicated.) An iteration count of zero causes the entire range to be omitted.

For example, the sequence

```
        DUP     2,3
        PZE     X
        PZE     Y
```

results in the sequence

```
        PZE     X
        PZE     Y
        PZE     X
        PZE     Y
        PZE     X
        PZE     Y
```

With the sole exception of the END pseudo-operation, any operation may appear within the range of a DUP, including another DUP.

If a DUP pseudo-operation occurs within the range of a preceding DUP, the two (or more) DUP pseudo-operations are said to be nested. As in most cases of nesting, the effect of nested DUP pseudo-operations must be determined beginning with the innermost one and working out. If the explicit range (the instruction count) of the inner DUP extends beyond the range of an outer DUP, the implicit range of the outer DUP is extended to the farthest point covered by the inner DUP. The first card to be processed after such a series of DUP pseudo-operations is the next card beyond both explicit and implicit DUP ranges.

For example, the operation

```
        DUP     m,n
```

duplicates the effect of the next *m* cards *n* times.

In the nested DUP pseudo-operations in the sequence

```
        DUP     1,2
        DUP     1,2
        PZE     X
        PZE     Z
```

the single card to be duplicated by the outer DUP is the inner DUP, and the effect of the inner DUP is actually the two operations

```
        PZE     X
        PZE     X
```

The sequence generated when the outer DUP is expanded is

```
        PZE     X
        PZE     X
        PZE     X
        PZE     X
        PZE     Z
```

where the last card in the sequence is the first card beyond both the explicit and implicit ranges of the outer DUP.

In the sequence

```
        DUP     3,2
        DUP     1,2
        PZE     X
        PZE     Y
        PZE     Z
```

The effect of the inner DUP is the sequence

```
        PZE     X
        PZE     X
```

The range of the outer DUP includes the two instructions resulting from the expansion of the inner DUP plus the two instructions following, i.e., PZE X and PZE Y.

Thus, the expansion of the outer DUP gives the sequence

```
            PZE     X
            PZE     X
            PZE     X
            PZE     Y
            PZE     X
            PZE     X
            PZE     X
            PZE     Y
            PZE     Z
```

The range of a DUP that occurs within the range of another DUP must be fixed before the *outer* DUP is encountered. This can be done by using the SET pseudo-operation. (See the section "The SET Pseudo-Operation.") For example, the sequence

```
K           SET     1
            DUP     2,2
K           SET     K+1
            DUP     K,n
```

will result in an error message and assembly will be terminated. However, the iteration count may be variable. For example, the sequence

```
K           SET     1
            DUP     2,2
K           SET     K+1
            DUP     m,K
```

is valid and will be assembled correctly. For example, the sequence

```
K           SET     1
            DUP     2,2
K           SET     K+1
            DUP     3,K
            PZE     X
            PZE     Y
            PZE     Z
```

would result in

```
            PZE     X
            PZE     Y
            PZE     Z
            PZE     X
            PZE     Y
            PZE     Z
            PZE     X
            PZE     Y
            PZE     Z
            PZE     X
            PZE     Y
            PZE     Z
            PZE     X
            PZE     Y
            PZE     Z
```

The variable field of a DUP pseudo-operation cannot be extended by use of the ETC pseudo-operation.

Symbol-Defining Pseudo-Operations

MAP provides a group of pseudo-operations specifically designed to define the symbols that appear in their name fields. They are useful in a variety of programming applications, such as equating symbols to combine separately written program segments or changing parameters referred to symbolically throughout a program by redefining the symbol.

The EQU and SYN Pseudo-Operations

The EQU and SYN pseudo-operations are identical. The format of the EQU and SYN pseudo-operations is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	EQU or SYN	One or two subfields, separated by a comma: 1. Any expression, 2. Modal and dimensional information

The EQU and SYN pseudo-operations give the name field symbol the same definition – and the same structure – as the expression in the first subfield of the variable field. Thus, if A is defined as X + Y − Z and the instruction

```
B           EQU     A
```

is given, B is defined as X + Y − Z. The instruction

```
LCS         EQU     *
```

defines LCS as having the current value of the location counter.

When the second subfield is used, it supplies to the debugging dictionary modal and dimensional information about the symbol in the name field. This subfield must be used if the symbol in the name field also appears in the variable field of a KEEP pseudo-operation. (See the publication *IBM 7090/7094 IBSYS Operating System: IBJOB Debugging Package,* Form C28-6393.) The format for this entry is

mode (d_1, d_2, d_3)

where d_1, d_2, and d_3 are the dimensions, if any, of the array denoted by the symbol in the name field, and mode is one of the letters O, F, X, D, J, L, S, C, or H, as explained in the discussion of the BSS pseudo-operation.

If the mode is omitted or is a symbol other than the nine listed above, it is assumed to be octal. Dimensions must be decimal integers or an error message is issued.

If the absolute value of the name field symbol is dependent upon the value of a virtual symbol, the S-value of the virtual symbol (which is zero) is used in the calculation of the debugging dictionary value.

For example, the instruction

```
NF          EQU     //+5
```

will result in a debugging dictionary entry for NF of relative location 5 of the deck being assembled.

The NULL Pseudo-Operation

The format of the NULL pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	NULL	Ignored

The NULL pseudo-operation defines the symbol in the name field, if any, as having the current value of the location counter. The operation

```
 LCS           NULL
```

is equivalent to

```
 LCS           EQU       *
```

except that NULL is preferred.

The MAX Pseudo-Operation

The MAX pseudo-operation gives the symbol in the name field an absolute value equal to the expression in the variable field that has the maximum defined value. The format of the MAX pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	MAX	Expressions, separated by commas

The maximum value is computed as if all symbols were absolute. The comparison is made after negative values have been complemented. For example, the sequence

```
               BSS       A
 A             MAX       100,ALPHA,ALPHA-100
 ALPHA         EQU       150
```

is equivalent to

```
               BSS       150
```

The MIN Pseudo-Operation

The effect of the MIN pseudo-operation is opposite to that of MAX. The symbol in the name field is given an absolute value equal to the expression in the variable field having the minimum defined value. The format of the MIN pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	MIN	Expressions, separated by commas

The minimum value is computed as if all symbols were absolute. The comparison is made after negative values have been complemented. For example, the sequence

```
               BSS       A
 A             MIN       100,ALPHA,ALPHA-100
 ALPHA         EQU       150
```

is equivalent to

```
               BSS       50
```

The SET Pseudo-Operation

The SET pseudo-operation causes the symbol in the name field to be defined immediately. The SET pseudo-operation, which can be used to define symbols in both machine instructions and pseudo-operations, is often used to define the symbols in the variable fields of the DUP, VFD, IFT, and IFF pseudo-operations. The format of the SET pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	SET	Any expression

Qualified symbols may not be used in the variable field. If an * is used as a location counter reference in the variable field, the assembler treats it as an ordinary symbol, gives it an S-value of zero, and issues an error message.

The symbol in the name field is immediately assigned the value (called the S-value) of the variable field expression during the first pass of the assembly program. Thus, the SET pseudo-operation enables the programmer to use sequences of instructions in which decisions depend on the value assigned to a symbol during the first pass of the assembly program. It also permits symbols to be redefined repetitively. The value assigned to the symbol is always a 15-bit integer.

Use of the SET pseudo-operation is subject to the following conditions:

1. Immediate symbols may not be qualified.
2. An immediate symbol used in the variable field of a pseudo-operation affecting location counters (such as BSS) assumes the final value assigned to it in the program. For example, the sequence

```
 A             SET       100
               BSS       A
 A             SET       1000
               END
```

is equivalent to

```
               BSS       1000
```

3. An immediate symbol should not normally be given a name identical to an ordinary symbol, since doing so can result in multiple definition.

An example of the use of the SET pseudo-operation to assign a value to a symbol during the first pass of the assembly program is shown in the following sequence.

```
 ALPHA         SET       50
               VFD       ALPHA/BETA
```

By using the SET pseudo-operation, the value of ALPHA can be changed without altering the VFD instruction. A similar use of immediate symbols is in making conditional assembly decisions with the IFF/IFT pseudo-operations.

The SET pseudo-operation permits a symbol to be redefined repeatedly for such programming functions as constructing tables and writing macro-operations. For example, in the sequence

```
 ALPHA         SET       1
               DUP       2,9
               PZE       ALPHA
 ALPHA         SET       ALPHA+1
```

ALPHA is first assigned a value of 1 and then redefined nine times with its value incremented by 1 at each iteration.

Boolean Pseudo-Operations

The Boolean pseudo-operations define symbols as Boolean quantities.

The BOOL Pseudo-Operation

The BOOL (Undesignated Boolean) pseudo-operation functions like the EQU pseudo-operation except that the variable field expression is Boolean and the name field symbol becomes a Boolean symbol. The format of the BOOL pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	BOOL	A Boolean expression

BOOL defines the symbol in the name field as an 18-bit constant. Relocatable symbols or virtual symbols used in the variable field result in an error. Octal integers in the variable field may not exceed six characters.

The RBOOL and LBOOL Pseudo-Operations

The format of the RBOOL (Right Boolean) and LBOOL (Left Boolean) pseudo-operations is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	RBOOL or LBOOL	A Boolean expression

Relocatable symbols or virtual symbols used in the variable field result in an error. Octal integers in the variable field may not exceed six characters.

These pseudo-operations are similar to BOOL except that the symbol in the name field is defined as right (left) Boolean. They are normally used to determine the correct machine operation for the special type D instructions (SIB, BNT, BFT, IIB, and RIB). The following mechanism is used.

1. If the expression in the variable field of an SIB instruction is entirely left (right) Boolean, the instruction is assembled as SIL (SIR). Constants are considered to be both left and right Boolean. If the expression is a mixture of both left and right Boolean, SIL is assembled but a warning message is issued.

2. If the variable field of an SIL (SIR) instruction is not purely left (right) Boolean, left (right) and undesignated Boolean, or purely undesignated Boolean, a warning message is issued.

For example, following the instructions

```
X          LBOOL    123
Y          RBOOL    456
Z          RBOOL    321
```

the instruction

```
BFT      X        assembles as LFT 123
BNT      Y        assembles as RNT 456
IIB      Z        assembles as IIR 321
RIB      Y+Z      assembles as RIR 777
SIB      Y+Z      assembles as SIL 323
```

A warning message is issued for the last instruction (SIB) because of the mixture of left and right Boolean.

Conditional-Assembly Pseudo-Operations

Two pseudo-operations provided by MAP enable the programmer to specify that the next instruction is to be assembled only if certain criteria are met. Another pseudo-operation, GOTO, may be used with the conditional-assembly pseudo-operations to extend their effect over more than one instruction.

The IFT and IFF Pseudo-Operations

The IFT (If True) and IFF (If False) pseudo-operations specify conditions that determine whether the next sequential instruction will be assembled. The format of the IFT and IFF pseudo-operations is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	IFT or IFF	1. element—relational operator—element 2. If present, either of the words OR or AND, preceded by a comma

The IFT (IFF) pseudo-operation assembles the next instruction if the condition expressed by the operation and the first subfield is met.

A relational operator consists of one or two adjacent symbols signifying:

=	Equals
=+	Greater than
=−	Less than

The elements at the left and right of these relations must not be qualified. The element is used in one of two ways:

1. To represent a numerical value equal to its S-value
2. To represent literal BCD information, in which case it is surrounded by slash (/) marks

Interpretation of the relational operator depends on the context. If the elements represent BCD, the relation is a scientific collating sequence comparison. For example,

```
IFT      /A/=+/B/
```

is false and would therefore not permit assembly of the next instruction. However,

```
IFT      /A/=-/B/
```

is true and would permit assembly of the next instruction.

Also,

```
        IFF       //=/A/
```

compares blank to A and would permit assembly of the next instruction.

If the elements represent a numeric quantity, the relation is a numeric comparison. The programmer must avoid noncomparable elements.

Presence of the second subfield signifies that another IFT or IFF is to follow, in which case the combined effect of the two is either a logical OR or a logical AND.

The S-value and not the definition is used in numeric evaluation of symbols. The SET pseudo-operation may be used to control IFF or IFT pseudo-operations, as in the sequence

```
K       SET       4
        IFT       K=4
```

This statement is true, and the next instruction will be assembled.

The fact that the conditional assembly extends over only one instruction is not a serious restriction, since the following instruction may be another IFT or IFF pseudo-operation, a GOTO pseudo-operation, or a macro-operation that expands to any length (see the section "Conditional Assembly in Macro-Operations").

The variable field of an IFF or IFT pseudo-operation may not be extended by using the ETC pseudo-operation.

The GOTO Pseudo-Operation

The GOTO pseudo-operation, when used with an IFT or IFF pseudo-operation, provides the MAP programmer with a method for either assembling or skipping blocks of instructions. The format of the GOTO pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	GOTO	One or two subfields, separated by a comma: 1. Symbol, which may be followed by a comma when used alone, 2. The word BLANK, which may be followed by a comma

The GOTO pseudo-operation causes all instructions following it, up to but not including the instruction whose name field contains the symbol specified in the variable field of this pseudo-operation, to be skipped during assembly.

If the BLANK option is present, the symbol in the variable field will not be entered into the dictionary but will appear on the listing. Therefore, the symbol, which may be completely numeric, may be reused.

If the variable field does not end with a comma, the skipped instructions are listed as comments. If the terminating comma is present, listing of skipped instructions is suppressed.

For example, the sequence

```
          CLA       X
          IFT       A=1
          GOTO      LCS
          STO       Z
           .
           .
           .
          CLA       B
LCS       TSX       SUB,4
```

would produce

```
          CLA       X
LCS       TSX       SUB,4
```

if A had previously been defined as 1, and

```
          CLA       X
          STO       Z
           .
           .
           .
          CLA       B
LCS       TSX       SUB,4
```

if A had been defined as some value other than 1.

In this example, the instructions omitted would be listed and LCS would be entered into the dictionary. Alternate forms would be

```
GOTO   LCS,BLANK      (LCS not entered, cards listed)
GOTO   LCS,           (LCS entered, no list)
GOTO   LCS,BLANK,     (LCS not entered, no list)
```

If a GOTO occurs within a macro-definition and the referenced symbol is outside the definition, only the instructions between the GOTO and the ENDM pseudo-operation are skipped. If a GOTO references past an IRP pseudo-operation, only the instructions between the GOTO and the IRP are skipped. The IRP iterations will not be terminated if any subarguments are left to be processed.

Symbol-Qualifying Pseudo-Operations

MAP provides two pseudo-operations, QUAL and ENDQ, that enable a programmer to qualify symbols within sections of a program.

The QUAL Pseudo-Operation

All symbols between the QUAL pseudo-operation and its associated ENDQ pseudo-operation are qualified. The format of the QUAL pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	QUAL	Symbol

The symbol in the variable field qualifies all symbols defined within the section controlled by the QUAL pseudo-operation. References to a symbol defined in a qualified section from within the same section need not be qualified. References from outside the section are qualified by placing the section symbol (variable field symbol of the QUAL pseudo-operation) in front of a connecting dollar sign followed by the desired symbol. For example, the symbol QS$ALPHA refers to symbol ALPHA defined in qualified section QS. The notation $BETA refers to symbol BETA, which is not qualified. The unqualified section effectively has a blank qualifier.

Qualified sections may be nested to provide multiple qualification. The range (from a QUAL to its corresponding ENDQ) of a lower-level QUAL must fall completely within the range of the next higher QUAL. A symbol is automatically qualified by any qualifiers of a higher level than the highest one specified in using the symbol. A multiply qualified symbol can be referenced without using all the qualifiers if enough qualifiers are given to determine the symbol uniquely. In any case, the qualifiers must be specified in the same order that nesting occurs within that section.

A sequence illustrating qualification is

```
        QUAL   H  }
A       BSS    1  }  Qualified
        CLA    X  }  Section H
        ENDQ   H  }
        QUAL   J  }  Qualified
A       BSS    1  }  Section J
        ENDQ   J  }
```

In this case, if X is written as A or H$A, it refers to the first definition of A; X written as J$A refers to the second definition of A.

In the sequence of nested qualification

```
        QUAL   M                 }
A       BSS    1                 }
        QUAL   N  }  Qualified   }  Qualified
        CLA    X  }  Section     }  Section M
        ENDQ   N  }  M$N         }
        ENDQ   M                 }
A       BSS    1
        CLA    Y
```

X written as A refers to the first definition of A; X written as $A refers to the second nonqualified A.
Y written as A refers to the second A; Y written as M$A refers to the first A.

In the more complicated sequence

```
        QUAL   ONE                          }
A       BSS    1                            }
        QUAL   TWO   }  Qualified           }  Quali-
A       BSS    1     }  Section             }  fied
        CLA    X     }  ONE$TWO             }  Section
        ENDQ   TWO   }                      }  ONE
        CLA    Y                            }
        ENDQ   ONE                          }

        QUAL   THREE                        }
A       BSS    1                            }  Quali-
        QUAL   TWO   }  Qualified           }  fied
A       BSS    1     }  Section             }  Section
        ENDQ   TWO   }  THREE$TWO           }  THREE
        ENDQ   THREE                        }
```

X refers to the first A by ONE$A; to the second A by A, by TWO$A, or by ONE$TWO$A; to the third A by THREE$A; and to the fourth A by THREE$TWO$A.

Y refers to the first A by A or by ONE$A; to the second A by TWO$A or by ONE$TWO$A; to the third A by THREE$A; and to the fourth A by THREE$TWO$A. In this sequence, the two sections TWO are distinct and not separate parts of the same section. The first is section ONE$TWO, and the second is section THREE$TWO.

The ENDQ Pseudo-Operation

The format of the ENDQ pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	ENDQ	Either: 1. A symbol, or 2. Blanks

ENDQ delimits the range of the qualified section whose symbol is in the variable field of this instruction. If the variable field is blank, the innermost qualified section is terminated. However, a low-severity warning message is issued, since a variable field inadvertently left blank can result in errors when using nested qualification.

In nested qualified sections, a separate ENDQ is required to terminate each qualified section. Also, qualified sections must be terminated in order beginning with the lowest level section as shown in the following sequence, or an error message will be issued.

```
QUAL     ALPHA
  .        .
  .        .
  .        .
QUAL     BETA
  .        .
  .        .
  .        .
QUAL     GAMMA
  .        .
  .        .
  .        .
ENDQ     GAMMA
  .        .
  .        .
  .        .
ENDQ     BETA
  .        .
  .        .
  .        .
ENDQ     ALPHA
```

Control-Section Pseudo-Operations

Relocatable programs can be divided into segments. By dividing large programs into relocatable segments, individual segments can be coded and checked in parallel, with consequent savings in time. Also, a segment can be modified without requiring reassembly of the entire program.

The control-section pseudo-operations provide the means for making references to and from such segments. IBLDR makes the cross-references among program segments that are assembled separately but loaded together. (For further information, see the publication *IBM 7090/7094 IBSYS Operating System: IBJOB Processor*, Form C28-6389.)

Each program segment is a control section. In addition, sections within segments may be designated as control sections by the programmer.

IBLDR treats control sections as being variable. A control section may be replaced by another control section or even deleted entirely. If more than one control section is given the same designation, generally only the first control section is retained.

An EVEN appearing within a control section must have the same relative location as the beginning of the control section. This will result in the first location of the control section being assigned an even location at load time. Thus, an instruction or data within a control section will be assigned to an even location if it appears an even distance from the control section origin.

The CONTRL Pseudo-Operation

The CONTRL pseudo-operation designates a program or a part of a program as a control section. The format of the CONTRL pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	CONTRL	One of the following: 1. A location counter symbol, or 2. A qualification symbol, or 3. Two subfields, separated by a comma, each containing an ordinary symbol

The CONTRL pseudo-operation delimits the control section named in the name field in accordance with the contents of the variable field. If a location-counter symbol is used in the variable field, all instructions under control of the specified location counter are delimited. The blank location counter cannot be used as a control section. If a qualification symbol is used, all instructions between the specified QUAL pseudo-operation and its associated ENDQ pseudo-operation are delimited. If two subfields are used, all instructions are delimited beginning at the location specified by the first symbol and ending at, but not including, the location specified by the second symbol. CONTRL pseudo-operations that refer to absolute symbols, or to location symbols whose definitions depend on an absolute origin within a relocatable assembly, are discarded and an error message is issued. An error message will also be given if a qualification symbol or location counter symbol defining a control section falls under an absolute origin. If the absolute origin occurs within the control section, no diagnostic will be given and relocation errors may occur during loading.

If there is no symbol in the name field, the first symbol in the variable field is taken as the external name of the control section and a low-severity message is issued. The length of a control section is always the difference between the value of the location counter in control at the end of the section and its value at the beginning of the section. Hence, the use of ORG or USE pseudo-operations within control sections may result in incorrect length calculations, in effect, "losing" instructions from the section. Text which has been placed within a control section by use of an ORG pseudo-operation *cannot* be deleted. Therefore, if several of such control sections with the same external name occur, the text from the last one encountered during loading will be used. If all of such control sections with the same external name are deleted, execution will be suppressed because of the resulting virtual reference which cannot be defined.

The CONTRL pseudo-operation may appear anywhere in the program. In an absolute assembly, a low-severity error message is printed, but CONTRL is otherwise ignored. For example,

```
X           CONTRL   A,B
```

defines the portion of the program from A to, but not including, B as control section X.

Control sections may be nested.

To obtain the blank COMMON area, as used by 7090/7094 FORTRAN IV, an instruction of the form

```
            CONTRL   //
```

must be used. For example, in the sequence

```
            CONTRL   //
            USE      A
              .
              .
              .
            USE      B
              .
              .
              .
            USE      //
            BSS      20
            USE      C
              .
              .
              .
            USE      A
              .
              .
              .
            END
```

the blank COMMON counter // will have its initial location defined as the last value reached by location counter C. The area under control of the // counter is a control section.

The ENTRY Pseudo-Operation

The ENTRY pseudo-operation provides a reference from outside a program segment to a point within the program segment. The format of the ENTRY pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	ENTRY	Symbol

The name field symbol becomes the external name of the entry point. The variable field symbol is the internal name of the entry point and must be an ordinary symbol, although it may be qualified. If the name field is blank, the variable field symbol serves as the external name. If the variable field symbol is qualified, the (leftmost) qualifier is used. For example,

```
ALPHA          ENTRY      BETA
```

specifies that ALPHA is the external name of an entry point into this program from another program and that BETA is the internal name of this entry point.

If an ENTRY pseudo-operation refers to either an absolute symbol, a symbol that was defined by an EQU or SYN pseudo-operation, or a location symbol whose definition depends on an absolute origin within a relocatable assembly, it is discarded and an error message is issued. The ENTRY pseudo-operation may also not refer to a location symbol whose definition depends upon a virtual origin.

File-Description Pseudo-Operations

Two pseudo-operations are provided by MAP for specifying input/output file requirements in relocatable assemblies. These pseudo-operations describe files that are used in conjunction with Library IOCS. (See the publication *IBM 7090/7094 IBSYS Operating System: Input/Output Control System,* Form C28-6345.)

IBLDR generates a file control block and assigns the file to a buffer pool. File control blocks described in one program segment may be referenced in other segments. If the same file is described more than once, only the first description is effective.

The FILE Pseudo-Operation

The FILE pseudo-operation enables the programmer to specify input/ output file requirements; it must appear within each program segment which references the file. The FILE pseudo-operation causes generation of a $FILE card, as well as any $ETC cards needed. The format of the FILE pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	FILE	External file name, options, . . .

The symbol in the name field of the FILE pseudo-operation is the internal name of the file used by the programmer within his program. Whenever this name appears in the variable field of an instruction, the relocatable reference is to the generated file control block for this file.

The first subfield of the variable field is the external file name. The order of the subsequent subfields is arbitrary.

In describing the subfields, options that may be included or omitted are shown in brackets. When an option is not specified, the standard option, which is shown underlined, is assumed. Braces indicate that a choice of the enclosed options is to be made by the user. Options are shown in all upper-case letters in the form in which they must be specified. Subfields in the variable field must be separated by commas.

External File Name is an alphameric literal of up to 18 BCD characters excluding blank, comma, slash, quotation mark, left and right parentheses, and asterisk used to determine equivalence between files. This subfield must be specified as the first subfield in the variable field. It may be null (the variable field may start with a comma), in which case the six-character name field (left-justified with trailing blanks) is inserted as the external name.

Unit-Assignment Option

[, primary unit]   [, secondary unit]

Two symbolic units may be specified for each file: the primary unit, and a secondary unit to be used as a reel-switching alternate. The format used for these specifications is indicated below, where the following notation is used:

X	a real channel (specified by one of the letters A through H)
P	a symbolic channel (specified by one of the letters S through Z)
I	an intersystem channel (specified by one of the letters J through Q)
k	a number (0-9) indicating the order of preference in assignment
a	access mechanism number (specified by either 0 or 1)
m	module number (specified by one of the numbers 0-9)
s	data channel switch or interface (specified by either of the numbers 0 or 1)
M	model number of 729 Magnetic Tape Unit (specified by II, IV, V, or VI)
D	1301/2302 Disk Storage (specified by the letter D)
N	7320 Drum Storage (specified by the letter N)
H	7340 Hypertape Drive (specified by the letter H)

The following format is used for assigning units:

SPECIFICATION	EFFECT
blank	Use any available unit.
M	Use any available 729 Magnetic Tape Unit of this model.
X	Use any available unit on this channel.
P	Use any available unit on this channel.
X(k)	Use *k*th available unit on the specified channel where the order of availability is based on ascending unit numbers. Parentheses are required.
PM	Use any available 729 Magnetic Tape Unit of specified model on designated symbolic channel.
P(k)M	Use *k*th available unit of the designated model on the specified symbolic channel where the order of availability is based on the availability chain. Parentheses are required.

I(k)	Use *k*th available unit on the specified intersystem channel where the order of availability is based on the availability chain. Parentheses are required. This specification can be used for input and output units.
I(k)M	Use *k*th available unit of the designated model on the specified intersystem channel where the order of availability is based on the availability chain. Parentheses are required. This specification can be used only for output units.
I(k)R	Use *k*th available unit on the specified intersystem channel where the order of availability is based on the availability chain, and release unit from reserve status after use. Parentheses are required.
XDam/s	Use 1301/2302 Disk Storage on channel X, access mechanism number *a*, and module number *m*.
XNam/s	Use 7320 Drum Storage on channel X, access mechanism *a* (0), module number *m* (0, 2, 4, 6, 8) and data channel switch setting *s* (0, 1).
XHk/s	Use 7340 Hypertape Drive on channel *X*, unit number k, and data channel switch *s*.
IN, IN1, IN2	Use the system input unit (SYSIN1) and the alternate system input unit (SYSIN2) as the primary and secondary units respectively.
OU, OU1, OU2	Use the system output unit (SYSOU1) and the alternate system output unit (SYSOU2) as the primary and secondary units respectively.
PP, PP1, PP2	Use the system peripheral punch (SYSPP1) and the alternate system peripheral punch (SYSPP2) as the primary and secondary units respectively.
UTk	Use system utility unit number *k*.
CKk	Use system checkpoint unit number *k*.
RDX	Use card reader on channel X.
PRX	Use printer on channel X.
PUX	Use card punch on channel X.
INT	File is internal.
*	An asterisk in the secondary unit field indicates that the secondary unit of a file is to be any unit on the same channel and of the same model as the primary unit.
NONE	No units are assigned. A file control block is generated but does not refer to a unit control block.

The IBJOB Loader (IBLDR), in an attempt to minimize tape mountings, tries to assign input requests to units in non-ready status and unlabeled output requests to ready units. Symbolic unit assignment, therefore, might not be in the exact order of the availability chain.

File-Mounting Option

$$\left[,\begin{Bmatrix}\underline{\text{MOUNT}}\\ \text{READY}\\ \text{DEFER}\end{Bmatrix}\right] \quad \text{and/or} \quad \left[,\begin{Bmatrix}\text{MOUNTi}\\ \text{READYi}\\ \text{DEFERi}\end{Bmatrix}\right]$$

The file-mounting option governs the on-line message to the operator indicating the impending use of an input/output unit. The first form applies to both units; the second applies to the primary unit when i=1 and to the secondary unit when i=2. Two standard options are indicated—one is for units assigned to system unit functions (READY) and the other is for nonsystem units (MOUNT).

The effects of these operations are:

MOUNT	A message is printed before execution, and a stop occurs for the required operator action. MOUNT is the standard option for nonsystem units.
READY	A message is printed before execution, but no stop occurs. READY is the standard option for all input/output units assigned to system unit functions.
DEFER	A message and operator stop are deferred until the file is opened by the IOCS calling sequence. TSX OPEN, 4 PZE internal file name

The i form of this option overrides for unit i any general option specified.

As an example of the file-mounting option.

MOUNT1, DEFER2

causes the MOUNT action for the primary unit and the DEFER action for the secondary unit.

Operator File-List Option

$$\left[,\begin{Bmatrix}\underline{\text{LIST}}\\ \text{NOLIST}\end{Bmatrix}\right]$$

LIST	This file will appear in the operator's mounting instructions.
NOLIST	No message will be printed unless the DEFER option has been specified.

File-Usage Option

$$\left[,\begin{Bmatrix}\underline{\text{INPUT}}\\ \text{OUTPUT}\\ \text{INOUT}\\ \text{CHECKPOINT (or CKPT)}\end{Bmatrix}\right]$$

INPUT	This is an input file.
OUTPUT	This is an output file.
INOUT	This file may be either an input or an output file. The object program sets the appropriate bits in the file block. The file is initially set at input.
CHECKPOINT (or CKPT)	This is a checkpoint file.

Block-Size Option

[, BLOCK=xxxx (or, BLK=xxxx)]

xxxx is an integer (0-9999) that specifies block size for this file. If the block-sequence and/or check-sum options (see below) are specified, a word must be added in determining block size. If the BLOCK option is omitted, the assembly program assumes a block size of 14 for BCD or MXBCD files and 256 for BIN and MXBIN files.

Activity Option

[, ACT=xx]

xx is an integer (0-99) that specifies activity of this file in relation to other files. If the activity subfield is omitted, activity is assumed to be 1. The activity value is used in determining the number of input/output buffers assigned to each buffer pool in the object program.

Reel-Handling Option

$\left[, \left\{\begin{array}{l}\underline{\text{ONEREEL}}\\ \text{MULTIREEL}\\ \text{(or REELS)}\end{array}\right\}\right]$ for unlabeled files only

ONEREEL	No reel switching should occur.
MULTIREEL (or REELS)	Reel switching will occur. Every output file will switch reels if an end-of-tape condition occurs.

$\left[, \left\{\begin{array}{l}\underline{\text{NOSEARCH}}\\ \text{SEARCH}\end{array}\right\}\right]$ for labeled files only

NOSEARCH	If an incorrect label is detected when opening an input file, IOCS causes a stop for operator action.
SEARCH	If an incorrect label is detected, IOCS enters a multireel search for the file with the desired label.

File-Density Option

$\left[, \left\{\begin{array}{l}\underline{\text{HIGH}}\\ \text{LOW}\\ \text{200}\\ \text{556}\\ \text{800}\end{array}\right\}\right]$

HIGH	Tape-density switch is assumed to be set so that execution of an SDH will result in using correct density.
LOW	Tape-density switch is assumed to be set so that execution of an SDL will result in using correct density.
200	Tape density switch is assumed to be set so that execution of an SDL will result in a file-recording density of 200 cpi.
556	Tape density switch is assumed to be set so that execution of an SDL will result in a file-recording density of 556 cpi.
800	Tape density switch is assumed to be set so that execution of an SDH will result in a file-recording density of 800 cpi.

If a system unit is assigned to this file, system set density supersedes the density specified by these options.

Mode Option

$\left[, \left\{\begin{array}{l}\underline{\text{BCD}}\\ \text{BIN}\\ \text{MXBCD}\\ \text{MXBIN}\end{array}\right\}\right]$

BCD	File is in BCD mode.
BIN	File is in binary mode.
MXBCD	File is in mixed mode, and first record is BCD.
MXBIN	File is in mixed mode, and first record is binary.

Label-Density Option

$\left[, \left\{\begin{array}{l}\underline{\text{SLABEL}}\\ \text{HILABEL}\\ \text{LOLABEL}\\ \text{FLABEL}\end{array}\right\}\right]$

SLABEL	All header label operations performed at installation standard density, which is currently high density.
HILABEL	All header label operations performed at high density.
LOLABEL	All header label operations performed at low density.
FLABEL	All header label operations performed at same density as file.

Regardless of these options, the LABEL pseudo-operation must be used to specify a labeled file. If label density is not specified, all label options are performed at the density that is high density at the particular installation.

Block-Sequence Option

$\left[, \left\{\begin{array}{l}\underline{\text{NOSEQ}}\\ \text{SEQUENCE}\\ \text{(or SEQ)}\end{array}\right\}\right]$

NOSEQ	Block-sequence word neither checked if reading, nor formed and written if writing.
SEQUENCE (or SEQ)	Block-sequence word checked if reading, or formed and written if writing.

Check-Sum Option

$\left[, \left\{\begin{array}{l}\underline{\text{NOCKSUM}}\\ \text{CKSUM}\end{array}\right\}\right]$

NOCKSUM	Check sum neither checked if reading, nor formed and written if writing.
CKSUM	Check sum checked if reading, or formed and written if writing.

Check-sum options may not be specified unless a block-sequence option has been specified.

Checkpoint Option

$\left[, \left\{\begin{array}{l}\underline{\text{NOCKPTS}}\\ \text{CKPTS}\end{array}\right\}\right]$

NOCKPTS	No checkpoints initiated by this file.
CKPTS	Checkpoints initiated by this file.

Checkpoint-Location Option

[, AFTER LABEL]

Checkpoints are written following the label on this file when reel switching occurs. If CKPTS is specified and this field is omitted, checkpoints are written on the checkpoint file when reel switching occurs.

File-Close Option

$\left[, \left\{\begin{array}{l}\underline{\text{SCRATCH}}\\ \text{PRINT}\\ \text{PUNCH}\\ \text{HOLD}\end{array}\right\}\right]$

SCRATCH	File is rewound at end of application.
PRINT	File is to be printed and is rewound and unloaded at end of application. PRINT will appear in on-line removal message at end of execution.
PUNCH	File is to be punched and is rewound and unloaded at end of application. PUNCH will appear in on-line removal instructions.
HOLD	File is to be saved and is rewound and unloaded at end of application. HOLD will appear in on-line removal instructions.

If the unit assigned is system input unit 1, system output unit 1, or system peripheral punch unit 1, the unit will not be rewound and the removal message will not be printed.

Starting Cylinder-Number Option

[, CYLINDER=xxx (or, CYL=xxx)]

xxx is the number (000-249 for disk, 000-009 for drum) of the starting cylinder for this file. The equals sign is required. When disk or drum storage is specified for a file, the starting cylinder number must be specified by the user.

Cylinder-Count Option

[, CYLCOUNT=xx (or, CYLCT=xxx)]

xxx is the number (000-250 for disk, 000-010 for drum) of consecutive cylinders to be used by this file. The equals sign is required. When disk or drum storage is specified for a file, cylinder count must be specified by the user.

Disk Write-Checking Option

[, WRITECK]

Write-checking is performed after each disk-write or drum-write sequence for this file.

Hypertape Reel-Switching Options

$$\left[, \begin{Bmatrix} \text{HRFP} \\ \text{HRNFP} \\ \text{HNRFP} \\ \underline{\text{HNRNFP}} \end{Bmatrix} \right]$$

These options may be used in conjunction with the Hypertape option, HYPER, where reel switching is likely to occur. If any of these options are used but HYPER is not specified, a warning message is issued.

The effects of these options are:

HRFP	Hypertape, rewind, file protect.
HRNFP	Hypertape, rewind, no file protect.
HNRFP	Hypertape, no rewind, file protect.
HNRNFP	Hypertape, no rewind, no file protect.

Five subfields provide information for cross-checking by IBLDR. These subfields, the conversion, block-size check, nonstandard label routine, Hypertape, and pool-attachment options, are not placed on the $FILE card.

Conversion Option

$$\left[, \begin{Bmatrix} \underline{\text{NOHCVN}} \\ \text{REQHCV} \\ \text{OPTHCV} \end{Bmatrix} \right]$$

NOHCVN	Alphameric-to-BCD conversion routine not necessary. File may not be assigned to card equipment.
REQHCV	Alphameric-to-BCD conversion routine required. File must be assigned to card equipment.
OPTHCV	Alphameric-to-BCD conversion optional.

Regardless of the conversion options specified, it is the responsibility of the programmer to provide the required conversion routines. File may be assigned to any input/output device.

Block-Size Check Option

$$\left[, \begin{Bmatrix} \text{MULTI=xxxx} \\ \text{MIN=xxxx} \end{Bmatrix} \right]$$

MULTI=xxxx	Block size is a multiple of xxxx.
MIN=xxxx	Minimum block size is xxxx.

Only one of the block-size check options may appear. The quantity specified is used by IBLDR to check the block size indicated by the BLOCK option. If neither option appears, block size is assumed to be exactly that specified by the BLOCK option.

Nonstandard-Label-Routine Option

[, NSLBL=symbol]

The symbol is the name of a nonstandard-label routine. If the label routine is part of the program segment being assembled, the label routine must be made a control section with the symbol used as its external name. If the label routine is not part of this program segment, the symbol must be a virtual symbol.

Hypertape Option

[,HYPER]

HYPER must be specified if a program requires Hypertape for a particular file. If reel switching may occur, the Hypertape reel-switching options may be used in conjunction with HYPER. However, use of Hypertape reel-switching options without specifying HYPER results in a warning message.

If a file may be attached to a Hypertape or a 729 Magnetic Tape Unit, the HYPER specification is not necessary.

Pool-Attachment Option

$$\left[, \begin{Bmatrix} \underline{\text{POOL}} \\ \text{NOPOOL} \end{Bmatrix} \right]$$

POOL	This file is to be attached to a pool.
NOPOOL	A file control block is to be generated, but this file is not to be attached to a pool.

If a CHECKPOINT (or CKPT) is specified for the file-usage option, NOPOOL is automatically assumed.

If the NOPOOL option is specified, it is assumed that the IOCS initialization sequences of .DEFIN and .ATTAC for this file will be executed by the object program prior to opening the file. (See the publication *IBM 7090/7094 IBSYS Operating System: Input/Output Control System,* Form C28-6345.)

Example of FILE pseudo-operation

For example, the options for an input file might be specified in the instruction

```
INPUT        FILE      ,A(1),READY,BLK=20,
                              556,HOLD
```

Since the first subfield is null, the symbol INPUT in the name field is regarded as the external name. The remaining subfields specify the first available unit on channel 1, the file-mounting option, a block size of 20 words, a file density of 556 characters per inch, and the file is to be saved and must be rewound and unloaded at the end of the application.

The LABEL Pseudo-Operation

The LABEL pseudo-operation enables the programmer to label a file and causes generation of the $LABEL control card. Whereas the FILE pseudo-operation describes the file characteristics, LABEL simply labels the file. The format of the LABEL pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	LABEL	Five subfields: 1. File name, 2. File serial number or disk or drum Home Address-2, 3. Reel sequence number, 4. Retention period (in days) or date, 5. File identification name

The file name is an alphameric name of eighteen or fewer BCD characters. If this subfield is null (the variable field begins with a comma), the symbol in the name field is inserted as the file name. If the name field is also blank, 000000 is inserted as the file name.

The file serial number is an alphameric subfield of five or fewer characters, and it may be null. If the label is for a file on disk or drum, this subfield must contain two BCD characters to specify the Home Address-2. (For further information, see the publication *IBM 1301, Models 1 and 2, Disk Storage and IBM 1302, Models 1 and 2, Disk Storage with IBM 7090, 7094, and 7094 II Data Processing Systems,* Form A22-6785.) The reel-sequence number is a numeric subfield of four or fewer digits and it may be null.

For retention period in days, four or fewer numeric characters are used. For date, two or fewer numeric characters represent the year, and three or fewer numeric characters represent the day of the year. The year and the day of the year are separated by the character / (slash).

The file identification name is an alphameric subfield of eighteen or fewer BCD characters. This subfield may contain blanks but not commas. A comma will terminate this subfield, and excessive subfields will be flagged as errors. This subfield may also be null.

For example,

```
LABEL          INVOICE,,241,63/248,PRIMARY FILE
```

specifies that the INVOICE file be labeled, provides its reel-sequence number of 241, dates it as the 248th day of 1963, and specifies PRIMARY FILE as the file identification name.

The variable field of the LABEL pseudo-operation must be contained on one card. No ETC cards may be used following LABEL.

The variable field is checked for errors. If there are more than five subfields, the variable field is truncated, only the first five subfields are used, and a warning message is printed. If there are fewer than five subfields, an appropriate number of commas is supplied so that the $LABEL card always has the required subfields and a warning message is printed.

Each subfield is then checked for length except for the last one. Subfields that are longer than the specified maximums are truncated to the maximum number of characters allowed for each, and a format error message is printed. Numeric subfields are also checked for validity, and the presence of any nonnumeric characters causes a format error message to be printed.

Operation-Defining Pseudo-Operations

Three pseudo-operations that define symbols as operation codes are provided by MAP.

The OPD Pseudo-Operation

The OPD (Operation Definition) pseudo-operation defines the symbol appearing in the name field as an operation code. The format of the OPD pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	OPD	12-digit octal machine operation code definition

The 12-digit machine operation code definition in the variable field must be specified according to the general format given in Appendix C.

The OPD pseudo-operation defines the symbol in the name field as an operation code. The symbol must be defined by the OPD pseudo-operation before its use in an operation field.

For example,

```
ALPHA      OPD       430106000500
```

defines ALPHA as an operation code having the same effect as the machine instruction CLA.

The OPVFD Pseudo-Operation

The OPVFD (Operation Variable Field Definition) pseudo-operation defines the symbol in the name field as the operation code represented by the expression in the variable field. The format of the OPVFD pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	OPVFD	From 1 to 36 subfields, separated by commas

The format of the variable field is the same as that given for the VFD pseudo-operation. The variable field expression must result in a 36-bit word having the format given in Appendix C.

The symbol in the name field becomes the mnemonic operation code of the instruction. The symbol must be defined by OPVFD before being used in an operation field.

For example,

```
ALPHA      OPVFD     O6/43,O5/00,O7/106,O6/00,
                     O12/0500
```

defines ALPHA as an operation code having the same effect as the machine instruction CLA.

The OPSYN Pseudo-Operations

The OPSYN (Operation Synonym) pseudo-operation equates the symbol in the name field to the mnemonic operation code in the variable field. The format of the OPSYN pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	OPSYN	Mnemonic operation code

The mnemonic operation code in the variable field must be a valid operation code (i.e., a machine operation code, a pseudo-operation code, a macro-operation code, or a code that has been defined previously by OPD, OPVFD, or another OPSYN).

If a previously defined operation code is redefined with OPD, OPVFD, or OPSYN, a warning message is issued. For example,

```
CLA          OPSYN     CAL
```

redefines CLA as CAL. The message warns the programmer of possible inadvertent redefinition of an existing operation code.

Miscellaneous Pseudo-Operations

The END Pseudo-Operation

The END pseudo-operation signals the end of the symbolic deck and terminates assembly. The END operation must be present and must be the last card in the symbolic deck. The format of the END pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	END	1. An element, or 2. Blanks

In a relocatable assembly, the value of the element in the variable field is the nominal starting point of the program segment.

The END pseudo-operation performs the following functions in an absolute assembly:

1. Any binary output waiting in the punch buffer is written out.
2. A binary transfer card to which control is transferred is produced. It has a transfer address that is the value of the expression in the variable field.

If UNPNCH is in effect, no cards are punched.

The ETC Pseudo-Operation

The variable field of most instructions may be extended over additional cards by using the ETC pseudo-operation. The format of the ETC pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Ignored	ETC	Subfields, separated by commas, or partial subfields

The ETC pseudo-operation appends its variable field as a continuation of the variable field of the previous instruction. The blank that separates the variable field from the comments field of a card is an end-of-card indicator and not an end-of-variable-field indicator. The number of ETC cards in one group is generally limited by the size of the resultant expression and/or the number of subfields. A variable-field expression is limited to about 100 elements, operators, and/or subfields. No element of an expression may be split between two cards. For example, the instruction

```
        TIX       NAME+1,4,1
```

could be written

```
        TIX       NAME+1
        ETC       ,4,1
```

or

```
        TIX
        ETC       NAME
        ETC       +1,4
        ETC       ,1
```

or

```
        TIX       NAME+1,4,
        ETC       1
```

but could not be written

```
        TIX       NA
        ETC       ME+1,4,1
```

The following operations may *not* be followed by an ETC card:

ABS	IFT	ORGCRS
BCI	INDEX	PCC
DEC	LABEL	PCG
DETAIL	LBL	PMC
DUP	LDIR	PUNCH
EJECT	LIST	QUAL
END	LORG	REM
ENDM	NOCRS	TITLE
ENDQ	NULL	TTL
EVEN	OCT	UNLIST
FUL	OPD	UNPNCH
IFF	OPSYN	USE

If an ETC follows any of these operations except END, the ETC will be ignored and a low-severity warning message issued.

The REM Pseudo-Operation

The REM (Remarks) pseudo-operation permits remarks to be entered into the assembly listing. The format of the REM pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Any information	REM	Any information

The contents of columns 8-10 (the operation field) are replaced by blanks, and the remaining contents of the card are copied onto the assembly listing. The REM pseudo-operation supplements the remarks card that has * in column 1. In a macro-definition, the variable field of the REM card is scanned for substitutable parameters, whereas the * card causes an error message but is otherwise completely ignored.

The KEEP Pseudo-Operation

The KEEP pseudo-operation permits the programmer to specify a debugging dictionary that contains only those symbols he wishes to use in debug requests. The format of the KEEP pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	KEEP	One or more symbols (which may not be qualified), separated by commas

The symbols in the variable field are entered into the debugging dictionary along with any modal and dimensional information that was supplied in BSS, BES, EQU, and SYN pseudo-operations. Any number of KEEP pseudo-operations may appear in a program. If the NODD option was specified on the $IBMAP card, the KEEP pseudo-operation is ignored. (For further information concerning debugging and the debugging dictionary, see the publications *IBM 7090/7094 IBSYS Operating System:* IBJOB Processor, Form C28-6389, and *IBM 7090/7094 IBSYS Operating System: IBJOB Processor Debugging Package*, Form C28-6393.)

Absolute-Assembly Pseudo-Operations

The pseudo-operations ABS, FUL, PUNCH, UNPNCH, and TCD are effective in absolute assemblies only. They are ignored in a relocatable assembly.

The ABS Pseudo-Operation

The ABS (Absolute) pseudo-operation specifies card output in the standard 22-word-per-card column-binary card format. The format of the ABS pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	ABS	Ignored

Binary cards are normally punched in the ABS mode unless otherwise specified. The ABS pseudo-operation always causes the next output word to start a new card. Any words remaining in the punch buffer are written out in the previously specified format.

Column-binary card format is described in the publication *IBM 7090/7094 IBSYS Operating System: IBJOB Processor*, Form C28-6389.

The FUL Pseudo-Operation

The FUL pseudo-operation specifies card output in the 24-word-per-card "full" mode. The format of the FUL pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	FUL	Ignored

The FUL pseudo-operation always causes the next output word to start a new card. Any words remaining in the punch buffer are written out in the previously specified format. Cards produced in the column binary full mode contain the first word of output in columns 1-3; the second, in 4-6; and so on to a maximum of 24 words per card. No control words or check sums are generated by the assembler in full mode.

The PUNCH and UNPNCH Pseudo-Operations

The PUNCH and UNPNCH pseudo-operations cause resumption and suspension, respectively, of binary card punching. The format of the PUNCH and UNPNCH pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	PUNCH or UNPNCH	Ignored

The TCD Pseudo-Operation

A binary transfer card directs an absolute loader program to stop loading cards and to transfer control to a designated location. In most cases, a transfer card is required at the end of the binary deck. In absolute assemblies, the END pseudo-operation causes a binary transfer card to be punched. However, the TCD pseudo-operation can cause a transfer card to be produced before the end of the binary deck.

The format of the TCD pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	TCD	A symbolic expression

The TCD pseudo-operation performs the following two functions:

1. Any binary output waiting in the punch buffer is written out.
2. A binary transfer card is produced. The format of the first word of this card is:

```
VFD      O12/5, 9/, 15/address
```

where address is the value of the expression in the variable field and is the transfer address. The rest of this card is blank except for serialization.

If UNPNCH is in effect, no cards are punched.

List-Control Pseudo-Operations

The PCC Pseudo-Operation

The PCC (Print Control Cards) pseudo-operation has the following format:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	PCC	Either: 1. ON 2. OFF 3. Blanks 4. Any information

Unless the UNLIST pseudo-operation is in effect, PCC ON causes the listing of the following cards: TTL, TITLE, LBL, LIST, INDEX, SPACE, EJECT, DETAIL, PCG, PMC, IFT, IFF, and GOTO, and any cards under the scope of the IFT, IFF, and GOTO pseudo-operations that are not assembled. PCC OFF suppresses listing of these cards and is the normal mode. The PCC card is always listed *unless UNLIST is in effect.* If the variable field is blank or contains anything other than ON or OFF, the current setting of the PCC switch is inverted.

The UNLIST Pseudo-Operation

The UNLIST pseudo-operation causes all listing to be suspended. The format of the UNLIST pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	UNLIST	Ignored

The UNLIST pseudo-operation is itself listed unless a previous UNLIST is still in effect. After an UNLIST, no lines are listed by the assembly program until a LIST or END pseudo-operation is encountered.

The LIST Pseudo-Operation

The LIST pseudo-operation causes listing to be resumed following an UNLIST. The format of the LIST pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	LIST	Ignored

The LIST pseudo-operation does not appear in the assembly listing unless the mode of PCC is ON.

The TITLE Pseudo-Operation

The TITLE pseudo-operation abbreviates the assembly listing by eliminating certain kinds of information. The format of the TITLE pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	TITLE	Ignored

TITLE causes the assembly program to exclude the following information from the listing:

1. Any line that contains octal information except the instruction that causes it, i.e., all but the first word generated by OCT, DEC, BCI, and VFD
2. All but the entire first iteration of each instruction in the range of a DUP
3. All complex fields in a relocatable assembly
4. The expansion of SAVE and all but the first three instructions in the expansion of CALL.
5. All literals in the Literal Pool except the first

A TITLE pseudo-operation is effective until the assembly program encounters a DETAIL operation. TITLE is not listed except when the mode of PCC is ON.

The DETAIL Pseudo-Operation

The DETAIL pseudo-operation causes the listing of generated data to be resumed after it has been suspended by a TITLE pseudo-operation. The format of the DETAIL pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	DETAIL	Ignored

The sole effect of the DETAIL operation is to cancel the effect of a previous TITLE pseudo-operation. If TITLE is not in effect, the DETAIL operation is ignored by the assembly program. The DETAIL operation does not appear in the assembly listing unless the mode of PCC is ON.

The EJECT Pseudo-Operation

The EJECT pseudo-operation causes the next line of the listing to appear at the top of a new page. The format of the EJECT pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	EJECT	Ignored

The EJECT pseudo-operation appears in the assembly listing only if the mode of PCC is ON.

The SPACE Pseudo-Operation

The SPACE pseudo-operation permits one or more blank lines to be inserted in the assembly listing. The format of the SPACE pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	SPACE	1. A symbolic expression, or 2. Blanks

The definition of the expression in the variable field determines the number of blank lines in the assembly listing. If the value of the expression is zero or the variable field is blank, one blank line appears. SPACE itself is listed only if the mode of PCC is ON.

The LBL Pseudo-Operation

Serialization of a deck normally begins with the first four characters of the deck name, which are left-justified and filled with trailing zeros. However, serialization can be altered by using the LBL pseudo-operation. The format of the LBL (Label) pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	LBL	One or two subfields, separated by a comma: 1. Up to 8 BCD characters, which may or may not be followed by a comma if the second subfield is not present 2. The word BEGIN followed by a blank or a comma

LBL causes binary cards to be identified and serialized in columns 73-80, as follows:

1. Serialization begins with the characters appearing in the variable field, which is left-justified and filled with terminating zeros.

2. Serialization is incremented by one for each card until the rightmost nonnumeric character or the seventh character is reached, after which the numeric portion recycles to zero. The two leftmost characters are regarded as fixed, even though they may be numeric.

For example, if the variable field is coded as ID, the first card is identified and serialized as ID000000.

If the variable field is coded as INSTR03, serialization is as follows:

```
INSTR030
INSTR031
   .
   .
   .
INSTR999
INSTR000
   .
   .
   .
```

If the BEGIN option is not included, reserialization begins with the binary card following the one that is currently being punched. Serialization can be altered at any point in the program by using additional LBL pseudo-operations.

If the BEGIN option is included, the LBL will be effective from the beginning of the program, serializing all binary cards, including the $FILE and $LABEL cards created by IBMAP as a result of the corresponding pseudo-operations, no matter where the LBL appears in the program. If more than one LBL pseudo-operation with the BEGIN option is used, only the last one will be effective. Any LBL pseudo-operations that do not contain the BEGIN option are processed normally.

If the variable field of the LBL currently in effect does not end with a comma, the assembly program prints the phrase

```
BINARY      CARD      ID.Number
```

at the beginning of each card. If a comma is used to terminate the variable field, printing of this phrase is suppressed. Printing of this phrase can be reinitiated by using an LBL pseudo-operation ending in a blank. LBL is listed only if the mode of PCC is ON.

The INDEX Pseudo-Operation

The INDEX pseudo-operation provides a table of contents of important locations within an assembly. The format of the INDEX pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	INDEX	Symbols, separated by commas

The first appearance of an INDEX card causes the message

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to be listed. Each subfield of an INDEX pseudo-operation causes the symbol and its definition to be listed. If a virtual symbol is used, its definition will be the control section number assigned to the symbol.

INDEX pseudo-operations may appear anywhere in the source program and need not be grouped. The listing generated by INDEX pseudo-operations is inserted where the pseudo-operations appear.

For meaningful commentary, INDEX pseudo-operations can be grouped and interspersed with explanatory remarks cards.

An INDEX pseudo-operation is not processed if any of the following three conditions exist:

1. It is in a macro-expansion and PMC is OFF.
2. It is in the range of a DUP pseudo-operation and a TITLE pseudo-operation is in effect.
3. An UNLIST pseudo-operation is in effect.

Listing of the INDEX card itself is governed by the mode of the PCC switch.

The variable field of an INDEX pseudo-operation cannot be extended by use of the ETC pseudo-operation.

The PMC Pseudo-Operation

The PMC pseudo-operation causes (or suppresses) listing of the card images generated by macro-instructions and by the RETURN pseudo-operation. The format of the PMC (Print Macro Cards) pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	PMC	Any one of: 1. ON 2. OFF 3. Blanks 4. Any information

ON in the variable field causes listing of the card images generated by macro-instructions; OFF, which is the normal mode, suppresses such listing. A blank variable field or one containing any information other than ON or OFF inverts the current setting of the PMC switch.

ETC cards extending the variable field of a macro-instruction are listed even if the mode of PMC is OFF.

Listing of the PMC card is controlled by the PCC pseudo-operation.

The TTL Pseudo-Operation

The TTL (Subtitle) pseudo-operation generates a subheading in the listing. The format of the TTL pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	TTL	A string of BCD characters starting in card column 12

Card columns 13-72 are used in words 4-13 of a generated subheading, which will appear on each page. TTL also forces a page ejection.

A subheading may be replaced by the variable field of another TTL and may be deleted by a TTL with a blank variable field.

Listing of the TTL card is controlled by the PCC pseudo-operation.

The PCG Pseudo-Operation

The PCG (Print Control Group) pseudo-operation causes listing of the relocatable control bits of each assembled word. The format of the PCG pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	PCG	Any one of: 1. ON 2. OFF 3. Blanks 4. Any information

ON in the variable field causes listing and OFF suppresses listing of the relocatable control bits for each assembled word. ON is the normal mode. A blank variable field or one containing any information other than ON or OFF inverts the current setting of the PCG switch. PCG is ignored in an absolute assembly.

PCG is listed if the mode of PCC is ON.

Special Systems Pseudo-Operations

Users of the MAP language are provided with a wide range of subroutines which are included in the systems library. A group of system pseudo-operations permits the transfer of control and data between the main program and the subroutine. Details about specific calling sequences are provided in the publications *IBM 7090/7094 IBYSY Operating System: IBJOB Processor,* Form C28-6389 and *IBM 7090/7094 Operating System: Input/Output Control System,* Form C28-6345.

The CALL Pseudo-Operation

The CALL pseudo-operation produces the standard IBJOB subroutine calling sequence. The format of the CALL pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	CALL	One or more subfields: 1. Symbol or ** 2. Calling sequence parameters 3. Error returns 4. Identification number

The first subfield in the variable field must contain an unqualified symbol (the name of a subroutine) or **. The next subfield contains the parameters of the calling sequence (if any), enclosed in parentheses and separated by commas. These may be any symbolic expression.

Error returns (if any), separated by commas, occupy the next subfield. The last subfield is an identification number (if desired), less than 32,768 and delimited by apostrophes. If specified, this number appears in the calling sequence in place of the assembly line number. When an identification number is not specified, the assembly line number appears.

For example, a typical CALL operation might be coded

```
LCS          CALL      name(arg1,arg2,...,argn)
             ETC       ret1,ret2,...,retn'id'
```

where name is the name of a subroutine; arg1, arg2, . . . , argn are the parameters of the calling sequence; ret1, ret2, . . . , retn are the error returns; and 'id' is the identification number.

A comma should not precede the left parenthesis, follow the right parenthesis, nor precede the 'id'.

If the subroutine is part of the program being assembled, the reference is to the routine in the program. However, if the subroutine is not part of the program being assembled, the symbol in the first subfield of the variable field becomes the external name of the subroutine called. If ** is used, a constant zero becomes the called address.

The remaining subfields generate the calling sequence.

Expansions of the CALL Pseudo-Operation

The linkage produced by

```
LCS        CALL      NAME(P1,...,Pn)R1,
           ETC       ...,Rm'ID'
```

is

```
LCS        TSX       NAME,4
           TXI       *+2+n+m,,n
           PZE       ID,,Linkage Director
           PZE       P1
           .
           .
           .
           PZE       Pn
           TRA       Rm
           .
           .
           .
           TRA       R1
```

where P is a subroutine parameter, R is an error return, *n* is the number of parameters and *m* is the number of error returns. The Linkage Director is a location unique for each assembly, and has no associated symbol. It may be given a symbolic designation using the LDIR pseudo-operation.

The operation

```
LCS        CALL      NAME(P1,P2)
```

produces

```
LCS        TSX       NAME,4
           TXI       *+2+2+0,,2
           PZE       Line number,,Linkage Director
           PZE       P1
           PZE       P2
```

The statement

```
LCS        CALL      NAME,R1
```

produces

```
LCS        TSX       NAME,4
           TXI       *+2+0+1,,0
           PZE       Line number,,Linkage Director
           TRA       R1
```

The statement

```
LCS        CALL      NAME
```

generates

```
LCS        TSX       NAME,4
           TXI       *+2+0+0,,0
           PZE       Line number,,Linkage Director
```

The SAVE Pseudo-Operation

The SAVE pseudo-operation produces the instructions necessary to save and restore the index registers and indicators, to disable and restore all operative traps, to provide error returns used by a subprogram, and to store the contents of index register 4 in SYSLOC and in the Linkage Director. The format of the SAVE pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	SAVE	Up to 7 subfields containing integers or immediate symbols and any or all of the letters I, D, E

The order in which the subfields in the variable field of the SAVE pseudo-operation are used is not important. All subfields are optional.

As many as 7 numeric subfields may be used to specify the index registers that are to be saved and restored. Immediate symbols may also be used to specify index registers. Any or all index registers may be specified in any order.

Index registers are saved in the order 4, 1, 2, 3, 5, 6, 7 and are restored in the opposite order. Index register 4 is automatically saved and restored, although it may still be specified.

One of the three remaining subfields is literally the character I; another is literally the character D; and the last is literally the character E.

The presence of I signifies that the sense indicators are to be saved and restored.

The presence of D causes all operative traps to be disabled and restored.

The presence of E generates the instructions necessary to facilitate use of error returns in the CALL pseudo-operation.

The contents of index register 4 are stored in the Linkage Director each time the SAVE pseudo-operation is executed. SYSLOC is a standard communication location used by all programs loaded under IBLDR. If the assembly is absolute (the ABSMOD option is specified), the symbol SYSLOC must be defined by the programmer.

The general form of the SAVE pseudo-operation is:

```
locsym     SAVE      (X1,...,Xk)I,D,E
```

or

```
locsym     SAVE      X1,...,Xk,I,D,E
```

Expansions of the SAVE Pseudo-Operation

The instruction

```
LCS        SAVE      2,1,I
```

or its equivalent

```
LCS        SAVE      (2,1)I
```

specifies that index registers 2 and 1 and the sense indicators are to be saved.

The expansion is:

```
              ENTRY     LCS
LCS           TXI       ..0003,,0
              AXT       **,2
              AXT       **,1
..0001        AXT       **,4
              LDI       ..0002+1
..0002        TRA       1,4
              PZE
..0003        STI       ..0002+1
              SXA       SYSLOC,4
              SXA       Linkage Director,4
              SXA       ..0001,4
              SXA       ..0001-1,1
              SXA       ..0001-2,2
```

The instruction

```
LCS           SAVE      2
```

generates

```
              ENTRY     LCS
LCS           TXI       ..0003,,0
              AXT       **,2
..0001        AXT       **,4
..0002        TRA       1,4
..0003        SXA       SYSLOC,4
              SXA       Linkage Director,4
              SXA       ..0001,4
              SXA       ..0001-1,2
```

In the next two examples, the instructions generated because of using the letters I, D, or E in the subfield of a SAVE pseudo-operation are identified by the appearance of the particular letter in the comments field of the generated instruction.

The instruction

```
LCS           SAVE      2,I,D
```

generates

```
              ENTRY     LCS
LCS           TXI       ..0003,,0
              AXT       **,2
..0001        AXT       **,4
              LDI       ..0002+1     I
              NZT       .TRPSW       D
              ENB*      .TRAPX       D
..0002        TRA       1,4
              PZE                    I
..0003        XEC       SYSDSB       D
              STI       ..0002+1     I
              SXA       SYSLOC,4
              SXA       Linkage Director,4
              SXA       ..0001,4
              SXA       ..0001-1,2
```

Locations .TRPSW and .TRAPX are words in the System Monitor IOEX communication table. A switch at .TRPSW indicates whether enabling is permissible at this time; .TRAPX gives the address of the location that contains the bits for proper enabling. (Note that the following enabling instruction refers to .TRAPX indirectly.) Location SYSDSB is a word in the IBJOB Monitor communication area that contains an enable instruction that uses a location containing zero. It is used here to disable traps.

The following sequence illustrates the expansion that is generated when the E option is specified:

```
LCS           SAVE      (2)I,D,E
```

generates

```
              ENTRY     LCS
LCS           TXI       ..0003,,**
              LDC       LCS,4        E
              SXD       *+5,4        E
              LAC       ..0001,4     E
              TXI       *+1,4,1      E
              SXA       *+1,4        E
              LXA       **,4         E
              TXI       *+1,4,**     E
              SXA       ..0002,4     E
              AXT       **,2
..0001        AXT       **,4
              LDI       ..0002+1     I
              NZT       .TRPSW       D
              ENB*      .TRAPX       D
..0002        TRA       **           E
              PZE                    I
..0003        XEC       SYSDSB       D
              STI       ..0002+1     I
              SXD       LCS,0        E
              SXA       SYSLOC,4
              SXA       Linkage Director,4
              SXA       ..0001,4
              SXA       ..0001-1,2
```

If the SAVE pseudo-operation has no symbol in the name field, a symbol will be generated and an error message will be printed.

The SAVEN Pseudo-Operation

The SAVEN pseudo-operation produces the instructions necessary to save and restore the index registers used by a subprogram. The format of the SAVEN pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	SAVEN	Up to 10 subfields

The SAVEN pseudo-operation is similar to SAVE except that the instructions

```
              ENTRY     LCS
              SXA       Linkage Director,4
```

are not generated. SAVEN is generally used when entering a subroutine from another subroutine without destroying the linkage information. If the SAVEN pseudo-operation has no symbol in the name field, a symbol will be generated and an error message will be printed. If the variable field is blank, index register 4 is saved and restored.

The RETURN Pseudo-Operation

The RETURN pseudo-operation is designed for use with CALL and SAVE, making use of the error (or alternate) returns used in these operations.

The format of the RETURN pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	RETURN	1 or 2 subfields separated by a comma: 1. A symbol, 2. An integer, a symbol, or an immediate symbol

The first subfield in the variable field of the RETURN pseudo-operation is required. It contains the name of the associated SAVE pseudo-operation. If the second subfield is present, it specifies the particular error return.

The RETURN pseudo-operation often takes the general form

```
name          RETURN    locsym,i
```

where locsym is the symbolic address of the associated SAVE pseudo-operation, and i is the desired error return (i=0 is the normal return).

The form of the RETURN instruction may vary. For example, to specify a particular error return (e.g., 2), the instruction

```
LOC           RETURN    LCS,2
```

is written, where LCS is the location of the SAVE pseudo-operation to be used. The following instructions are generated:

```
LOC           AXT       2,4
              SXD       LCS,4
              TRA       LCS+1
```

If the E option of the SAVE or SAVEN pseudo-operation is not used, the following form should be used:

```
              RETURN    LCS
```

which generates

```
              TRA       LCS+1
```

This form should also be used even where the E option is specified if the error return is inserted into the decrement of the SAVE or SAVEN pseudo-operation at execution time.

The variable field of the RETURN pseudo-operation may not be left blank, since it results in a TRA instruction with a blank variable field. The PMC pseudo-operation governs the listing of the instructions generated by the RETURN pseudo-operation.

Part III. The Macro-Operation Facility

Macro-operations are special types of pseudo-operations that provide the MAP user with a powerful programming tool. After a programmer has defined a macro-operation, he can cause a whole sequence of instructions to be called into a program by coding a single instruction. The sequence can be repeated as often as desired. Moreover, any field or subfield of any instruction in the sequence can be changed each time the sequence is repeated.

Any machine instruction, pseudo-operation, or macro-operation can be included in a macro-operation. The sequence of instructions generated (usually called a macro-expansion) is an open subroutine. The instructions are executed in-line with the rest of the program.

Two general requirements must be met to take advantage of the macro-operation facility. First, the macro-operation must be defined by a macro-definition. Then, wherever the sequence of instuctions is desired in the program, it must be called by a macro-instruction.

Defining Macro-Operations

A macro-definition provides a name for the macro-operation, determines the instructions that will be included in the macro-expansion, and establishes the parts of the instructions that are to be variable.

Three kinds of instructions must be coded to define a macro-operation. The first is the MACRO pseudo-operation. (The card containing this instruction is sometimes called the macro-definition heading card.) Prototype instructions (sometimes called prototype card images) immediately follow the MACRO pseudo-operation to establish the instructions that will be generated in the macro-expansion. Finally, the ENDM pseudo-operation ends the macro-definition.

The MACRO Pseudo-Operation

The MACRO pseudo-operation establishes the name of a macro-operation. The format of the MACRO pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
BCD name up to 6 characters long	MACRO	Up to 63 substitutable arguments (groups of not more than 6 characters) separated by punctuation characters

The name in the name field becomes the name of the macro-operation that is being defined. This name is later used to call the macro-operation and thus, in effect, becomes an operation code. Any valid symbol may be used in the name field of the MACRO pseudo-operation, or all numeric characters may be used. However, six zeros may not be used.

The name in the name field of a MACRO pseudo-operation may be the same as a symbol used anywhere in the program, even in this or any other macro-operation. However, if this name is the same as any other machine operation code, pseudo-operation code, or macro-operation code, the operation code is redefined.

The subfields in the variable field of the MACRO pseudo-operation contain substitutable arguments.

SUBSTITUTABLE ARGUMENTS IN THE MACRO PSEUDO-OPERATION

Much of the flexibility of the macro-operation facility results from the principle of substitutable arguments. These subfields in the variable field of the MACRO pseudo-operation are dummy names that will be replaced in the macro-expansion.

Substitutable arguments permit any field or subfield of any instruction to be changed each time the macro-operation is called. The programmer can also change parts of subfields and even add entire instructions.

A substitutable argument is from one to six characters long. Any valid symbol may be used, and the name of a substitutable argument may consist of all numeric characters. For example, in the MACRO pseudo-operation

```
ALPHA       MACRO    ABC,123
```

each of the two groups of three characters in the variable field is a substitutable argument.

No punctuation characters except the period may be used as part of a substitutable argument.

A substitutable argument may be the same as a symbol or an operation code, including the operation code for this or any other macro-operation. However, substitutable arguments should not be identical to symbols or operation codes used in the prototype that immediately follows unless the symbols or operation codes are actually intended to be substitutable arguments.

DELIMITING SUBSTITUTABLE ARGUMENTS IN THE MACRO PSEUDO-OPERATION

Substitutable arguments in the variable field of the MACRO pseudo-operation may be separated by any of the following punctuation (special) characters:

= + −* / ( ),'

If parentheses are used, they must be used in pairs.

The use of these characters permits meaningful notation in a macro-definition. For example,

```
ALPHA        MACRO     23,RATE,TIME,DIST,
                                  QUSYM
```

could also be written

```
ALPHA        MACRO     23(RATE*TIME=DIST)
                                  QUSYM
```

The variable field of the MACRO pseudo-operation may be extended over more than one card by using the ETC pseudo-operation. When the substitutable arguments appear on more than one card, the blank character acts as a separator. Hence, no punctuation character is needed between consecutive substitutable arguments that appear on separate cards. For example,

```
BETA         MACRO     A,B,C
```

could also be written

```
BETA         MACRO     A,B
             ETC       C
```

This usage of the ETC pseudo-operation differs from the usual case, in which all punctuation characters must be written.

Consecutive punctuation characters or an explicit zero are ignored and do not result in a substitutable argument of zero.

Prototypes in Macro-Definitions

The prototype of a macro-definition determines the instructions that will be included in the macro-expansion, their sequence in the expansion, and the positions of the substitutable portions of the instructions. The prototype, which consists of one or more prototype instructions, immediately follows the MACRO pseudo-operation.

A prototype instruction is similar to any other instruction. It has a name field, an operation field, and a variable field. It may also have a comments field, although this field does not appear in the card image generated in the macro-expansion. The distinguishing feature of a prototype instruction is that parts of it can be made variable.

The fields or subfields of a prototype instruction may contain text or substitutable arguments.

TEXT IN PROTOTYPES

Text represents the fixed parts of the instructions that will be generated in the macro-expansion. Any part of a prototype instruction that has not been made a substitutable argument by its appearance in the variable field of the MACRO pseudo-operation is treated as text. For example, in the prototype

```
ALPHA        MACRO     A,B
             CLA       A
             B         BUFFER
             .
             .
             .
```

the operation code CLA and the location BUFFER are text. (BUFFER has been defined elsewhere in the program.)

Text is reproduced in the macro-expansion exactly as it appears in the prototype instruction. Thus, if only text is used in a field of an instruction, it must conform to the rules governing that field of the instruction in which it is used. For example, if the operation field of a prototype instruction is text, it must be a valid operation code.

Since parentheses can be used to delimit substitutable arguments within the prototype, parentheses must be used carefully as part of text to avoid confusing the enclosed characters with a substitutable argument.

SUBSTITUTABLE ARGUMENTS IN PROTOTYPES

Substitutable arguments represent the variable parts of the instructions that will be generated in the macro-expansion. The same substitutable arguments are used in the prototype that appeared in the variable field of the MACRO pseudo-operation. However, in the prototype, substitutable arguments appear in the fields or subfields of the prototype instructions that are to be variable. A substitutable argument may appear in any field or subfield of a prototype instruction. For example, in the sequence.

```
BETA         MACRO     ONE,TWO,THREE
ONE          CLA       PART1
             TWO       PART2
             STO       THREE
             .
             .
             .
```

ONE, TWO, and THREE are substitutable arguments in the name, operation, and variable fields, respectively, of prototype instructions.

DELIMITING SUBSTITUTABLE ARGUMENTS IN PROTOTYPES

The same punctuation (special) characters may be used in prototype instructions that were used to separate the substitutable arguments in the variable field of the MACRO pseudo-operation. Except for the apostrophe, these characters are reproduced in the macro-expansion. Only the aspostrophe may be used to delimit substitutable arguments in the variable fields of REM and TTL pseudo-operations and the data subfields of BCI pseudo-operations. (Another use of the apostrophe in macro-operations is explained in the section "Combining Substitutable Arguments and Text.")

A comma or a left parenthesis immediately following the operation code (as near the beginning of the card as column 11) signifies the end of the operation field and the beginning of the variable field.

A blank delimits a substitutable argument in a prototype. For example, in the macro-definition (where b represents a blank)

```
XYZ        MACRO   A,B,C
           AbbbB
```

three blanks separate A (in the operation field) from B (in the variable field). It is not always necessary that three blanks separate these two fields, but at least three characters are used for an operation field code. In this example, A and two blanks are used, whereas the third blank is required to terminate the operation field. If fewer blanks separated A from B, both would be taken as part of the operation code, causing errors.

If a blank is encountered before card column 72 in the variable field of a prototype instruction other than a BCI, REM, or TTL pseudo-operation, the card is terminated. Substitutable arguments may appear anywhere from column 1 through column 72 on BCI, REM, and TTL cards. Any information to the right of the blank will not be included in the macro-definition.

Every field or subfield of six or fewer characters in any field of a prototype instruction is compared with the substitutable arguments in the variable field of the MACRO pseudo-operation. Therefore, care must be taken to avoid confusing fields intended as text with fields intended as substitutable arguments.

Cards with an asterisk (*) in column 1 (remarks cards) may be interspersed with macro-definition cards but will not be included in the macro-expansion.

The ENDM Pseudo-Operation

The ENDM pseudo-operation terminates a macro-definition. The format of the ENDM pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	ENDM	Either: 1. One or two subfields, separated by a comma, or 2. Blanks

The ENDM pseudo-operation immediately follows the last prototype instruction and ends the macro-definition. An ENDM pseudo-operation is required for every MACRO pseudo-operation.

The first of the two subfields permitted in the variable field of the ENDM pseudo-operation is a BCD name of up to six characters. If a name is used in this subfield, it must be the same as the name used for the corresponding MACRO pseudo-operation. If the first subfield is not used, but the second is, a comma must precede the second subfield.

If the second subfield in the variable field of the ENDM pseudo-operation is present, it specifies either CRS (create symbols) or NOCRS (no created symbols). The second subfield controls symbol creation for this macro-operation only, overriding the effect of the NOCRS and ORGCRS pseudo-operations (see the section "Created Symbols"). CRS in this subfield always causes and NOCRS always suppresses symbol creation each time the macro-operation is called. Any symbol other than CRS or NOCRS has no effect.

For example, in the macro-definition

```
ALPHA      MACRO   A,B
           CLA     A
           ADD     B
           STO     SUM
           ENDM    ALPHA,NOCRS
```

the ENDM pseudo-operation is coded so that symbol creation is suppressed whenever this macro-operation is called.

If the variable field or the first subfield of the variable field is blank, this and all unterminated macro-definitions are terminated (see the section "Nested Macro-Operations").

Calling Macro-Operations

After a macro-operation has been defined, it may be called so that the generated sequence of instructions is brought into a program at a desired point. In the macro-expansion, each prototype instruction in the macro-definition is reproduced. Text and all punctuation characters except the apostrophe are reproduced exactly as they appeared in the prototype. However, the substitutable arguments that appeared in the variable field of the MACRO pseudo-operation and in the prototype are replaced by the actual parameters that the programmer wishes to appear in the expansion. These parameters are provided in the macro-instruction, which is used to call the macro-operation.

The Macro-Instruction

The macro-instruction calls a previously defined macro-operation into a program. The format of the macro-instruction is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	Macro-operation name	Parameters, separated by commas or enclosed in parentheses.

If there is a symbol in the name field, it is assigned to the first instruction of the macro-expansion.

The name that was assigned in the name field of the MACRO pseudo-operation is an operation code and is used in the operation field of the macro-instruction.

The variable field of the macro-instruction contains the actual parameters that the programmer wishes to appear in the macro-expansion.

PARAMETERS IN MACRO-INSTRUCTIONS

The parameters in the variable field of the macro-instruction replace the substitutable arguments that appeared in the macro-definition. These parameters must appear in the same order as the substitutable arguments they are to replace originally appeared in the variable field of the MACRO pseudo-operation.

The length of a parameter in the variable field of a macro-instruction is not limited to six characters as is a substitutable argument. The variable field of a macro-instruction may be extended over more than one card by using the ETC pseudo-operation. However, a single parameter must appear completely on one card unless it is enclosed in parentheses.

Macro-instruction parameters consist of any appropriate character or group of characters that would normally appear in the particular instruction. For example, in the macro-definition.

```
QPOLY       MACRO    COEFF,LOOP,DEG,T,OP
            AXT      DEG,T
            LDQ      COEFF
LOOP        FMP      GAMMA
            OP       COEFF+DEG+1,T
            XCA
            TIX      LOOP,T,1
            ENDM     QPOLY
```

mnemonic symbols represent the substitutable arguments. LOOP appears in a name field, OP in an operation field, and COEFF, DEG, and T appear in subfields of the variable field. GAMMA is text and not a substitutable argument, since it does not appear in the variable field of the MACRO pseudo-operation. In this macro-instruction, a symbol should be substituted for LOOP and a valid operation code for OP. Such a macro-instruction might be written

```
X015        QPOLY    C1-4,FIRST,5,4,FAD
```

The macro-expansion would cause the following six card images to be generated.

```
X015        AXT      5,4
            LDQ      C1-4
FIRST       FMP      GAMMA
            FAD      C1-4+5+1,4
            XCA
            TIX      FIRST,4,1
```

The symbol X015 is assigned to the first instruction, and each substitutable argument is replaced by the corresponding parameter that appeared in the variable field of the macro-instruction.

DELIMITING MACRO-INSTRUCTION PARAMETERS

The parameters in the variable field of a macro-instruction are separated either by commas or parentheses. A single comma following a right parenthesis or preceding a left parenthesis is redundant and may be omitted. Neither of these combinations results in a null parameter. A null parameter is indicated by two consecutive commas or by a single comma at the beginning of the variable field. If the blank terminating the variable field is preceded by a comma, the last subfield is not null (see the example in the section "Created Symbols"). An explicit zero must be used to obtain a zero parameter.

Parentheses around data used as a macro-instruction parameter signify that everything within the parentheses, including blanks, is to replace the corresponding substitutable argument in the prototype. (In fact, if blanks are to be included in a macro-instruction parameter, the parameter must be enclosed in parentheses.) For example, the macro-definition

```
XYZ         MACRO    A,B
            A
B
            ENDM     XYZ
```

followed by the macro-instruction

```
            XYZ      (AXTbbbbb10,1)
            ETC      (ALPHAbbTRAbbbbbBETA,1)
```

results in the expansion

```
            AXT      10,1
ALPHA       TRA      BETA,1
```

If parentheses are to appear in a macro-expansion, they must be enclosed in an outer pair of parentheses. The outer parentheses are removed in the expansion.

Pairs of parentheses must be balanced. For example, given the macro-definition

```
CALLIO      MACRO    IOCOM,T1,OP,LABEL,T2
            ETC      TAPNO,PFX,ERRET
            TSX      (TAPE),4
            PZE      IOCOM,T1,OP
            PZE      LABEL,T2,TAPNO
            IFT      ERRET=1
            PFX      ERRET
            ENDM     CALLIO
```

and using the following parameters in place of the substitutable arguments

IOCOM – CITIO	T2 – null
T1 – 2	TAPNO – CITTAP
OP – (RBEP)	PFX – null
LABEL – CITLB	ERRET – null

the corresponding macro-instruction would be

```
                CALLIO     CITIO,2,((RBEP)),CITLB
                ETC        ,CITTAP,,,
```

This macro-instruction could also be written

```
                CALLIO     CITIO,2((RBEP))CITLB
                ETC        ,CITTAP,,,
```

since the commas around ((RBEP)) are redundant.

Note that TAPE must not be a substitutable argument and that (RBEP) must be enclosed in outer parentheses. Also, an explicitly null parameter appears in the macro-instruction at a position corresponding to the substitutable argument ERRET in the macro-definition. This null parameter causes the fifth word of the expansion to be omitted.

Inserting Instructions into Macro-Expansions

A single parameter in a macro-instruction may include more than one field or even an entire instruction to replace a single substitutable argument that appeared in a field of a prototype instruction. The parameter is inserted into the field in which the original substitutable argument appeared, and it may extend to other fields to the right of the field in which it is inserted. For example, if a substitutable argument appeared in the operation field of a prototype instruction, a parameter could be inserted that would have an operation field and a variable field.

When a parameter consists of more than one field or is an entire instruction, the programmer must provide enough blanks in the parameter so that the fields of the instruction appear in their proper positions in the macro-expansion.

In the following example, a substitutable argument in the operation field of a prototype instruction is replaced by an instruction having an operation field and a variable field. The macro-definition.

```
XYZ             MACRO      A,B,C,
                CLA        A
                B
                STO        C
                ENDM       XYZ
```

followed by the macro-instruction

```
SUM             XYZ        ALPHA(ADDbbbbbBETA)
                ETC        GAMMA
```

results in the macro-expansion

```
                CLA        ALPHA
                ADD        BETA
                STO        GAMMA
```

Conditional Assembly in Macro-Operations

The IFT and IFF pseudo-operations may be used to determine whether instructions within a macro-expansion are assembled. For example, the sequence

```
ADDM            MACRO      B,C,D
                CLA        B
                ADD        C
                IFF        /D/=/AC/
                STO        D
```

allows the sum to be stored if the name substituted for D is not literally the characters AC and prevents it from being stored if the name is the characters AC.

If the IFF pseudo-operation in the above example were replaced by

```
                IFT        D=1
```

the sum would be stored only if the parameter substituted had already appeared in the name field of some instruction (i.e., if the S-value of D is 1).

The two conditions can be combined to obtain

```
                IFF        /D/=/AC/,AND
                IFT        D=1
```

which assembles the store operation only if D is not literally AC and has appeared before in a name field.

Combining Substitutable Arguments and Text

The apostrophe can be used to combine substitutable arguments and text to form a single prototype subfield. The apostrophe delimits a substitutable argument in a macro-definition prototype but is not itself included in the macro-expansion. However, the apostrophe may not be used to combine partial subfields in lower-level nested macro-definitions (see the section "Nested Macro-Operations").

For example, given the macro-definition

```
ALPHA           MACRO      A,B,C
                BCI        A,bb'B'bERROR,b
                              CONDITION'C'b
                                     IGNORED
                ENDM       ALPHA,NOCRS
```

the macro-instruction

```
                ALPHA      6,(FIELD),,
```

causes the following instruction to be generated:

```
                BCI        6,bbFIELDbERROR,b
                                CONDITIONb
                                    IGNORED
```

By using the apostrophe, instructions within macro-operations can be altered and even name field symbols can be changed. For example, the macro-definition

```
FXCY            MACRO      B,W,Z,Y,T
N'B             PXA        Y,T
                PAC        0,4
                'W'X'Z     Y,4
                ENDM       FXCY
```

after the macro-instruction

```
                FXCY       AME,S,A,DATA,1
```

results in the sequence

```
NAME      PXA     DATA,1
          PAC     0,4
          SXA     DATA,4
```

The name field may not exceed six characters in the prototype, including substitutable arguments, text, and punctuation characters. The operation field may not exceed six characters or six characters and an asterisk.

Nested Macro-Operations

A macro-definition may be included completely within the prototype of another higher-level macro-definition. When the higher-level macro-operation is expanded, the MACRO pseudo-operation and the prototype of the lower-level macro-operation are generated. Thus, a macro-instruction for a lower-level macro-operation cannot be used until all higher-level macro-operations have been expanded.

A new macro-operation may be defined or an existing macro-operation redefined, depending on whether the name of the lower-level macro-operation appears as text or as a substitutable argument in the higher-level macro-operation. For example, in the macro-definition

```
MAC1      MACRO   MAC2,ALPHA,BETA
          ETC     GAMMA,DELTA
MAC2      MACRO   ALPHA
          BETA    A
          GAMMA   B
          DELTA   C
          ENDM    MAC2
          ENDM    MAC1
```

the lower-level macro-operation, MAC2, appears as a substitutable argument. The macro-instruction

```
          MAC1    ABC,(A,B,C),CLA,ADD,STO
```

generates

```
ABC       MACRO   A,B,C
          CLA     A
          ADD     B
          STO     C
          ENDM    ABC
```

which defines a macro-operation, ABC, where A, B, and C are substitutable arguments; and CLA, ADD, and STO are text.

However, had MAC2 appeared as text rather than as a substitutable argument in the macro-definition of MAC1, MAC2 would be redefined each time MAC1 was expanded.

There is no significant limit to the depth of nesting permitted.

Macro-Instructions in Macro-Definitions

The prototype of a macro-definition may include macro-instructions for which macro-operations have not yet been defined. However, these macro-instructions must be defined before using a macro-instruction that expands the macro-operation. Care must be exercised to avoid a macro-definition loop. For example, if macro-operation A contains an unconditional call on macro-operation A (a macro-instruction for A), a macro-definition loop will result. However, if the call on macro-operation A is conditional (i.e., there is provision for eventual exit from the loop), a macro-operation A may contain a macro-instruction for A.

Data enclosed within parentheses may be used as a parameter in a macro-instruction. When a macro-instruction is used within another macro-definition, special handling of data containing blanks is required. Such data must be replaced by a substitutable argument in the outer macro-definition. The actual data must appear as a parameter in the macro-instruction. An additional pair of parentheses must surround the data (already within a single pair of parentheses) to ensure proper substitution.

For example, in the macro-definition

```
MAC1      MACRO   A,C
          CLA     C
          MAC     A,(AXTbb**,4b)
          STO     A
          ENDM    MAC1
```

MAC is a previously defined macro-operation. Proper substitution would not occur, because a blank terminates the variable fields of prototype instructions except for the BCI, REM, and TTL pseudo-operations. Instead, the following sequence should be used:

```
MAC1      MACRO   A,C,D
          CLA     C
          MAC     A,D
          STO     A
          ENDM    MAC1
```

When using the macro-instruction MAC1, the substitution would be

```
          MAC1    X,Y,((AXTbb**,4b))
```

The resulting generated sequence is

```
          CLA     Y
          MAC     X,(AXTbb**,4b)
          STO     X
```

The macro-instruction for MAC can now cause the data to be substituted properly.

Qualification Within Macro-Operations

The qualification in effect when the macro-instruction is used will be used for symbols in the macro-expansion. If a qualification symbol is required within a macro-definition, it may be a substitutable argument, as may the symbols it qualifies.

If a macro-expansion having a qualified section falls within the range of a qualified section in the program, the rules for nested qualification apply when referring to symbols within the macro-expansion.

Macro-Related Pseudo-Operations

The IRP pseudo-operation is used to supplement the definition of macro-operations, whereas ORGCRS and NOCRS are used in macro-expansions.

The IRP Pseudo-Operation

The IRP (Indefinite Repeat) pseudo-operation causes a sequence of instructions within a macro-operation to be repeated with one parameter varied at each repetition. The format of the IRP pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	IRP	1. A single substitutable argument, or 2. Blanks

To repeat a sequence of instructions, two IRP pseudo-operations are required within a macro-definition — one to initiate the sequence and the other to end it. A single substitutable argument that originally appeared in the variable field of the preceding MACRO pseudo-operation must appear in the variable field of the initial IRP pseudo-operation. The variable field of the second IRP pseudo-operation is left blank.

For example, the operation

```
                IRP       A
```

initiates a sequence, whereas

```
                IRP
```

ends the sequence.

Substitutable argument A governs the iteration of the instructions. If a symbol other than a single substitutable argument or more than one subfield appears in the variable field of the first IRP pseudo-operation, the pseudo-operation is ignored and a warning message is issued.

In the macro-instruction, substitutable argument A is replaced by one or more subarguments enclosed in parentheses and separated by commas. Each time the macro-instruction is used, the assembly program generates the sequence of instructions with each of the subarguments used successively in place of suitable argument A. If only one subargument is used, the sequence of instructions will be generated only once. If no subarguments are given, the whole sequence will be skipped. If a blank appears within the parentheses, only the arguments to the left of the blank will be effective. However, if a comma immediately precedes a blank, the Assembler construes the blank following the comma as a subargument consisting of a blank character. If the subarguments of an instruction card are to be continued on subsequent ETC cards, any card encountered before the right parenthesis must be filled through column 72. If necessary, a name may be split between two cards.

For example, given the macro-definition

```
XYZ         MACRO     ARG,B
            IRP       ARG
            CLA       ARG
            ADD       B
            STO       ARG
            IRP
            ENDM      XYZ
```

the macro-instruction

```
            XYZ       (J,K,L),CONST
```

generates

```
            CLA       J      )
            ADD       CONST  } (First iteration, with
            STO       J      )         subargument J)
            CLA       K      )
            ADD       CONST  } (Second iteration, with
            STO       K      )         subargument K)
            CLA       L      )
            ADD       CONST  } (Third iteration, with
            STO       L      )         subargument L)
```

Given the macro-definition

```
ABC         MACRO     IT
            IRP       IT
            CLA       IT
            IRP
            ENDM      ABC
```

the macro-instruction

```
            ABC       (A1,A2,A3
            ETC       A4,A5)
```

generates

```
            CLA       A1
            CLA       A2
            CLA       A3
            CLA
```

and the macro-instruction

```
                                               72
            ABC       (ABCD1,ABCD2,ABCD3,...,AB
            ETC       CD10,ABCD11)
```

generates

```
            CLA       ABCD1
            CLA       ABCD2
            CLA       ABCD3
             .
             .
             .
            CLA       ABCD10
            CLA       ABCD11
```

If the substitutable argument does not appear between the two IRP pseudo-operations, the generated sequences will be identical, their number depending on the number of subarguments given.

For example, given the macro-definition

```
BBB         MACRO     C,D,E
            IRP       C
            CLA       D
            STO       E
            IRP
            ENDM      BBB
```

the macro-instruction

```
            BBB       (1,2,3),DATA1,DATA2
```

generates

```
CLA     DATA1
STO     DATA2
CLA     DATA1
STO     DATA2
CLA     DATA1
STO     DATA2
```

An IRP pseudo-operation may not occur explicitly within the range of another IRP. Such a nested pair causes termination of the first range and opening of a second range. However, a macro-instruction within the range of an IRP pseudo-operation may itself cause pairs of IRP pseudo-operations to be generated at a lower level.

Created Symbols

If parameters are missing from the end of the variable field of the macro-instruction, symbols are created to fill the vacancies. These symbols take the form

```
..0001
..0002
  .
  .
  .
..nnnn
```

No created symbols are supplied for an explicitly null argument. Created symbols are supplied only at the end of the parameters.

For example, if the MACRO pseudo-operation

```
ALPHA        MACRO    A,B,C
```

is followed by the macro-instruction

```
             ALPHA    X,,
```

substitutable argument A is replaced by X, substitutable argument B is omitted since the parameter is explicitly void, and substitutable argument C is replaced by a symbol of the form . . nnnn. This symbol is created to replace the omitted parameter at the end of the variable field of the macro-instruction.

Given the macro-definition

```
XFAD        MACRO    N,B,C,D,E,A,X
            SXA      A,4
            AXT      N,4
X           CLA      B,4
            IFF      /C/=//
            F'C      D,4
            STO      E,4
            TIX      X,4,1
A           AXT      **,4
            ENDM     XFAD,CRS
```

the macro-instruction

```
            XFAD     4,DATA,AD,DATA1,DATA2
```

generates

```
            SXA      ..0001,4
            AXT      4,4
..0002      CLA      DATA,4
            FAD      DATA1,4
            STO      DATA2,4
            TIX      ..0002,4,1
..0001      AXT      **,4
```

However, the macro-instruction

```
            XFAD     4,DATA,,,DATA2
```

generates

```
            SXA      ..0001,4
            AXT      4,4
..0002      CLA      DATA,4
            STO      DATA2,4
            TIX      ..0002,4,1
..0001      AXT      **,4
```

In this example, the number of instructions can vary between references, making a relative-address reference difficult. However, by permitting the assembly program to generate the names, the references are correct without requiring programmer-specified names.

The NOCRS Pseudo-Operation

The NOCRS pseudo-operation suppresses symbol creation, which causes missing parameters at the end of the variable field of the macro-instruction to be treated as if they were explicitly null. The format of the NOCRS pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	NOCRS	Ignored

The ORGCRS Pseudo-Operation

The ORGCRS pseudo-operation may be used to alter the form of created symbols. This pseudo-operation also causes symbol creation to be resumed if it has been suppressed by a NOCRS. The format of the ORGCRS pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	ORGCRS	1. Blanks, or 2. Up to 4 numeric digits, or 3. One BCD character and up to 4 numeric digits.

If a BCD character appears in the variable field, it replaces the second period of the created symbols. If digits appear, they will be the origin of the new set of created symbols. This origin will be one lower than the first symbol actually created. If fewer than four digits are used, they will be right-justified with leading zeros. If no digits are supplied or if the variable field is blank, the number will continue from the last created symbol.

With a blank variable field, the ORGCRS pseudo-operation causes resumption or continuation of symbol creation.

The PURGE Pseudo-Operation

The PURGE pseudo-operation removes from core storage prototypes of macro-operations that are no longer needed, thus providing space for other prototypes. However, the PURGE pseudo-operation does not remove the name of the macro-operation from the name table. The format of the PURGE pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	PURGE	A list of macro-operation names, separated by commas

If an entry in the variable field of a PURGE pseudo-operation is not the name of a macro-operation, it is ignored and no message is issued.

If a macro-operation is redefined, purging of the previous form is automatic (a PURGE pseudo-operation is not needed).

If a call is made to a purged macro-operation, the call will be ignored and an error message will be issued.

Appendix A: Machine Operations

All machine operations recognized by MAP are tabulated in this appendix, including supplementary information about their format and use. Listings are provided of the 7090 machine operations, extended machine operations, special operations, 7094 machine operations, 7909 data channel commands, 1301 disk file orders, and 7340 Hypertape orders.

The code letters used under identical column headings have the same significance in all tables. The BCD name of the machine operation is given in the column headed Mnemonic.

Type indicates machine-instruction format characteristics by code letters having the following meanings:

CODE	MEANING
A	15-bit decrement field
B	No decrement field
C	8-bit decrement field
D	18-bit address field
E	13-bit address field
K	4-bit prefix field
L	Disk orders

The codes in the address (Addr), tag, and decrement (Decr) columns signify:

CODE	MEANING
R	Subfield required. If missing, error message FIELD REQUIRED is issued.
P	Subfield permitted. Neither its presence nor absence results in a message.
U(n)	Subfield unexpected. If present, message FIELD NOT EXPECTED is issued. Assembly program truncates definition value of subfield to number of bits (n) shown in parentheses and, treating this value as a constant, adds it to value normally appearing in subfield.
N	Subfield not allowed. If present and its value is not zero, message FIELD NOT ALLOWED is issued. Its value is always treated as a constant zero.

If the size of a subfield differs from normal, field size is indicated in parentheses following the subfield letter code.

In the column headed Ind, the letter (P) indicates that indirect addressing is permitted and (N) indicates that is is not permitted.

7090 Machine Operations

MNEMONIC	TYPE	ADDR	TAG	DECR	IND
ACL	B	R	P	U(4)	P
ADD	B	R	P	U(4)	P
ADM	B	R	P	U(4)	P
ALS	B	R	P	U(6)	N
ANA	B	R	P	U(4)	P
ANS	B	R	P	U(4)	P
ARS	B	R	P	U(6)	N
AXC	B	R	R	U(6)	N
AXT	B	R	R	U(6)	N
BSF	B	R	P	U(6)	N
BSR	B	R	P	U(6)	N
BTT	E	R	P	U(6)	N
CAL	B	R	P	U(4)	P
CAQ	C	R	P	R(8)	N
CAS	B	R	P	U(4)	P
CHS	E	N	P	U(6)	N
CLA	B	R	P	U(4)	P
CLM	E	N	P	U(6)	N
CLS	B	R	P	U(4)	P
COM	E	N	P	U(6)	N
CRQ	C	R	P	R(8)	N
CVR	C	R	P	R(8)	N
DCT	E	N	P	U(6)	N
DVH	B	R	P	U(4)	P
DVP	B	R	P	U(4)	P
ECTM	E	N	P	U(6)	N
EFTM	E	N	P	U(6)	N
ENB	B	R	P	U(4)	P
ENK	E	N	P	U(6)	N
ERA	B	R	P	U(4)	P
ESNT	B	R	P	U(4)	P
ESTM	E	N	P	U(6)	N
ETM	E	N	P	U(6)	N
ETT	E	R	P	U(6)	N
FAD	B	R	P	U(4)	P
FAM	B	R	P	U(4)	P
FDH	B	R	P	U(4)	P
FDP	B	R	P	U(4)	P
FMP	B	R	P	U(4)	P
FRN	E	N	P	U(6)	N
FSB	B	R	P	U(4)	P
FSM	B	R	P	U(4)	P
HPR	B	P	P	U(6)	N
HTR	B	R	P	U(4)	P
IIA	B	P	P	U(6)	N
IIL	D	R(18)	N	U(6)	N
IIR	D	R(18)	N	U(6)	N
IIS	B	R	P	U(4)	P
IOT	E	N	P	U(6)	N
IOCD	A	R	N	R	P
IOCP	A	R	N	R	P
IORP	A	R	N	R	P
IOCT	A	R	N	R	P
IORT	A	R	N	R	P
IOSP	A	R	N	R	P
IOST	A	R	N	R	P
LAC	B	R	R	U(6)	N
LAS	B	R	P	U(4)	P
LBT	E	N	P	U(6)	N
LCHx	B	R	P	U(4)	P
LDC	B	R	R	U(6)	N
LDI	B	R	P	U(4)	P
LDQ	B	R	P	U(4)	P
LFT	D	R(18)	N	U(6)	N
LFTM	E	N	P	U(6)	N
LGL	B	R	P	U(6)	N
LGR	B	R	P	U(6)	N
LLS	B	R	P	U(6)	N
LNT	D	R(18)	N	U(6)	N
LRS	B	R	P	U(6)	N

MNEMONIC	TYPE	ADDR	TAG	DECR	IND
LSNM	E	N	P	U(6)	N
LTM	E	N	P	U(6)	N
LXA	B	R	R	U(6)	N
LXD	B	R	R	U(6)	N
MPR	B	R	P	U(4)	P
MPY	B	R	P	U(4)	P
MSE	E	R	P	U(6)	N
NOP	B	P	P	U(6)	N
NZT	B	R	P	U(4)	P
OAI	B	P	P	U(6)	N
OFT	B	R	P	U(4)	P
ONT	B	R	P	U(4)	P
ORA	B	R	P	U(4)	P
ORS	B	R	P	U(4)	P
OSI	B	R	P	U(4)	P
PAC	B	P	R	U(6)	N
PAI	B	P	P	U(6)	N
PAX	B	P	R	U(6)	N
PBT	E	N	P	U(6)	N
PDC	B	P	R	U(6)	N
PDX	B	P	R	U(6)	N
PIA	B	P	P	U(6)	N
PSE	E	R	P	U(6)	N
PXA	B	P	R	U(6)	N
PXD	B	P	R	U(6)	N
RCHx	B	R	P	U(4)	P
RCT	E	N	P	U(6)	N
RDCx	E	N	P	U(6)	N
RDS	B	R	P	U(6)	N
REW	B	R	P	U(6)	N
RFT	D	R(18)	N	U(6)	N
RIA	B	P	P	U(6)	N
RIL	D	R(18)	N	U(6)	N
RIR	D	R(18)	N	U(6)	N
RIS	B	R	P	U(4)	P
RND	E	N	P	U(6)	N
RNT	D	R(18)	N	U(6)	N
RQL	B	R	P	U(6)	N
RUN	B	R	P	U(6)	N
SBM	B	R	P	U(4)	P
SCHx	B	R	P	U(4)	P
SDN	B	R	P	U(6)	N
SIL	D	R(18)	N	U(6)	N
SIR	D	R(18)	N	U(6)	N
SLQ	B	R	P	U(4)	P
SLW	B	R	P	U(4)	P
SSM	E	N	P	U(6)	N
SSP	E	N	P	U(6)	N
STA	B	R	P	U(4)	P
STD	B	R	P	U(4)	P
STI	B	R	P	U(4)	P
STL	B	R	P	U(4)	P
STO	B	R	P	U(4)	P
STP	B	R	P	U(4)	P
STQ	B	R	P	U(4)	P
STR	A	P	P	P	N
STT	B	R	P	U(4)	P
STZ	B	R	P	U(4)	P
SUB	B	R	P	U(4)	P
SXA	B	R	R	U(6)	N
SXD	B	R	R	U(6)	N
TCH	A	R	N	U(6)	P
TCNx	B	R	P	U(4)	P
TCOx	B	R	P	U(4)	P
TEFx	B	R	P	U(4)	P
TIF	B	R	P	U(4)	P
TIO	B	R	P	U(4)	P
TIX	A	R	R	R	N
TLQ	B	R	P	U(4)	P
TMI	B	R	P	U(4)	P
TNO	B	R	P	U(4)	P
TNX	A	R	R	R	N
TNZ	B	R	P	U(4)	P
TOV	B	R	P	U(4)	P
TPL	B	R	P	U(4)	P
TQO	B	R	P	U(4)	P
TQP	B	R	P	U(4)	P
TRA	B	R	P	U(4)	P
TRCx	B	R	P	U(4)	P
TSX	B	R	R	U(6)	N
TTR	B	R	P	U(4)	P
TXH	A	R	R	R	N
TXI	A	R	R	R	N
TXL	A	R	R	R	N
TZE	B	R	P	U(4)	P
UAM	B	R	P	U(4)	P
UFA	B	R	P	U(4)	P
UFM	B	R	P	U(4)	P
UFS	B	R	P	U(4)	P
USM	B	R	P	U(4)	P
VDH	C	R	P	R(6)	P
VDP	C	R	P	R(6)	P
VLM	C	R	P	R(6)	P
WEF	B	R	P	U(6)	N
WRS	B	R	P	U(6)	N
XCA	B	P	P	U(6)	N
XCL	B	P	P	U(6)	N
XEC	B	R	P	U(4)	P
ZET	B	R	P	U(4)	P

Extended Operations

MAP provides a group of sense and select-type extended operation codes for programmer convenience. These codes permit the address portion of certain instructions to be specified symbolically as part of the operation code, rather than octally in the address portion of the instruction. These codes also provide more meaningful mnemonics for some machine instructions.

MAP also recognizes a group of prefix codes that can be used in such programming applications as forming constants or in subroutine calling sequences.

SENSE TYPE

The following extended operation codes of the sense type are recognized by the assembly program. The tag subfield is permitted in all these operation codes, but indirect addressing is not permitted in any of them. The letter x is to be replaced by one of the channel letters.

MNEMONIC	ADDR	DECR
BTTx	N	U(6)
ETTx	N	U(6)
SLF	N	U(6)
SLN	R	U(6)
SLT	R	U(6)
SPRx	R	U(6)
SPTx	N	U(6)
SPUx	R	U(6)
SWT	R	U(6)

SELECT TYPE

The following extended operation codes of the select type are recognized by the assembly program. The tag subfield is permitted in all these operation codes, but indirect addressing is not permitted in any of them. If the following instructions are used in a relocatable deck, the address field must contain an integer or an immediate symbol. The letter x is to be replaced by a channel letter.

MNEMONIC	ADDR	DECR
BSRx	R	U(6)
BSFx	R	U(6)
RCDx	N	U(6)
REWx	R	U(6)
RPRx	N	U(6)
RTBx	R	U(6)
RTDx	R	U(6)
RUNx	R	U(6)
SDHx	R	U(6)
SDLx	R	U(6)
WEFx	R	U(6)
WPBx	N	U(6)
WPDx	N	U(6)
WPUx	N	U(6)
WTBx	R	U(6)
WTDx	R	U(6)

PREFIX CODES

The following prefix codes are recognized by the assembly program. All have 15-bit decrement fields (Type A) with address, tag, and decrement permissible. Indirect addressing is permitted for all prefix codes.

MNEMONIC	MEANING	PREFIX
FIVE	Five	5
FOR	Four	4
FOUR	Four	4
FVE	Five	5
MON	Minus One	5
MTH	Minus Three	7
MTW	Minus Two	6
MZE	Minus Zero	4
ONE	One	1
PON	Plus One	1
PTH	Plus Three	3
PTW	Plus Two	2
PZE	Plus Zero	0
SEVEN	Seven	7
SIX	Six	6
SVN	Seven	7
THREE	Three	3
TWO	Two	2
ZERO	Zero	0

Special Operations

The following special operations recognized by MAP reduce coding effort for frequently occurring conditions. Indirect addressing is not permitted in any of these operations.

MNEMONIC	TYPE	ADDR	TAG	DECR	ASSEMBLES AS
BFT	D	R	N	N	LFT(RFT)
BNT	D	R	N	N	LNT(RNT)
BRA	A	R	N	P	TXL
...	A	P	P	P	PZE
***	A	P	P	P	PZE
	A	P	P	P	PZE
IIB	D	R	N	N	IIL(IIR)
RIB	D	R	N	N	RIL(RIR)
SIB	D	R	N	N	SIL(SIR)
ZAC	B	U	N	U(6)	PXD
ZSA	B	R	N	U(6)	SXA
ZSD	B	R	N	U(6)	SXD

(See the section "The RBOOL and LBOOL Pseudo-Operations" for a description of special type D instructions.)

7094 Machine Operations

The following 7094 machine operations are recognized by MAP. In a 7090 assembly, these operations are replaced by system macro-instructions (see Appendix B) with the exceptions noted below. The 7090 system macro-instructions closely approximate the effects of the 7094 machine operations but may cause slight differences in the precision of the results obtained.

If a subfield is to be supplied at execution time, the notation ** must be used. The field may not be left blank.

MNEMONIC	TYPE	ADDR	TAG	DECR	IND
DFAD	B	R	P	U(4)	P
DFAM	B	R	P	U(4)	P
DFDH	B	R	P	U(4)	P
DFDP	B	R	P	U(4)	P
DFMP	B	R	P	U(4)	P
DFSB	B	R	P	U(4)	P
DFSM	B	R	P	U(4)	P
DLD	B	R	P	U(4)	P
DST	B	R	P	U(4)	P
*DUAM	B	R	P	U(4)	P
*DUFA	B	R	P	U(4)	P
*DUFM	B	R	P	U(4)	P
*DUFS	B	R	P	U(4)	P
*DUSM	B	R	P	U(4)	P
*EMTM	E	N	P	U(6)	N
*LMTM	E	N	P	U(6)	N
PCA	B	P	R	U(6)	N
PCD	B	P	R	U(6)	N
SCA	B	R	R	U(6)	N
SCD	B	R	R	U(6)	N

*These 7094 instructions are not replaced by macro-instructions when assembling in the 7090 mode; they are assembled as NOP instructions, and a low-severity message is issued.

IBM 7909 Data Channel Commands

The following 7909 data channel commands are recognized by the assembly program. An x in the operation code is to be replaced by a channel letter.

MNEMONIC	TYPE	ADDR	TAG	DECR	IND
CPYD	A	R	N	R	P
CPYP	A	R	N	R	P
CTL	K	R	N	N	P
CTLR	K	R	N	N	P
CTLW	K	R	N	N	P
(1)ICC	K	P	N	N	N
LAR	K	R	N	N	P
LCC	K	R	N	N	P
LIP	K	P	N	N	N
LIPT	A	R	N	U(4)	P
RICx	E	N	P	U(6)	N
RSCx	B	R	P	U(4)	P
SAR	K	R	N	N	P
SCDx	B	R	P	U(4)	P
SMS	K	R	N	N	P
SNS	K	P	N	N	N
STCx	B	P	P	U(4)	P
(1)TCM	K	R	N	R	P
TDC	K	R	N	N	P

MNEMONIC	TYPE	ADDR	TAG	DECR	IND
TWT	K	R	N	N	P
WTR	A	R	N	U(4)	P
XMT	A	R	N	R	P

(1) A count field in the high-order position of the decrement is assembled from the fourth subfield of the variable field. For example,

```
                    ICC         ,,,4
```

IBM 1301 Disk and 7320 Drum File Orders

The following disk and drum file orders are recognized by MAP. The symbolic order should be written:

```
Location        DORD        access and module, track, record
```

and assembles as ten BCD digits in two successive locations.

MNEMONIC	ACCESS AND MODULE	TRACK	RECORD
DEBM	P	P	P
DNOP	P	P	P
DREL	P	P	P
DSAI	P	P	P
DSBM	P	P	P
DSEK	P	P	P
DVCY	P	P	P
DVHA	P	P	P
DVSR	P	P	P
DVTA	P	P	P
DVTN	P	P	P
DWRC	P	P	P
DWRF	P	P	P

The access/module and track subfields may be any symbolic expression. They are evaluated in the normal manner and converted to BCD. The low-order two characters of the access/module subfield and the low-order four characters of the track subfield are inserted into the instruction. The record subfield is taken as alphameric data, and the first two characters are used. A DNOP (1212_8) order is inserted in the last two character positions of the second word.

IBM 7340 Hypertape Orders

The following Hypertape orders are recognized by MAP. The symbolic order should be written:

```
Location        HORD        Tape unit (if required)
```

and assembles as two (or three for HSBR and HSEL) BCD characters, left-justified in the word. Locations containing two-character orders are filled with trailing HNOP (1212_8) codes. Three-character orders are repeated in the rightmost three characters.

MNEMONIC	TAPE UNIT
HBSF	N
HBSR	N
HCCR	N
HCHC	N
HCLN	N
HEOS	N
HERG	N
HFPN	N
HNOP	N
HRLF	N
HRLN	N
HRUN	N
HRWD	N
HSBR	R
HSEL	R
HSKF	N
HSKR	N
HUNL	N
HWTM	N

Any symbolic expression may be used in the tape unit subfield. The expression is evaluated and converted to BCD, and the low-order character is used as the Hypertape unit number (0-9).

Appendix B: 7090 Macro-Expansions of 7094 Instructions

When assembling in the 7090 mode, certain 7094 instructions are replaced by equivalent 7090 macro-instructions. The expansions of these macro-instructions are provided in this appendix.

The expansions are divided into groups in which only a few instructions vary from the given operation code. The generic macro-expansion of each group is given with the necessary substitutions.

In this appendix, the symbols E.1, E.2, E.3, and E.4 are generated by the expansions as names of temporary storage locations. However, these symbols must be defined by the programmer or they will be virtual. The symbol is generated and defined by the expansion even if the mode of the created symbol switch is NOCRS.

Relative addressing must be used carefully when 7090 macro-expansions of 7094 instructions are used. The reason for this, of course, is that the single macro-instruction appearing in the source program will be replaced by a group of 7090 instructions during assembly.

For example, at first glance the following sequence of instructions appears to be a loop that will form five, double-precision, floating-point products, where

1. the first factor of each product is composed of the contents of location ALPHA + i and BETA + i (i = 0,1,2,3,4),
2. the second factor is composed of the contents of locations MULT and MULT + 1,
3. each product replaces its first factor in storage, and
4. multiplication does not occur if the contents of ALPHA + i are negative.

```
            AXT         5,2
            CLA         ALPIIA+5,2
            LDQ         BETA+5,2
            TMI         XXX+3
XXX         DFMP        MULT
            STO         ALPHA+5,2
            STQ         BETA+5,2
            TIX         *-6,2,1
```

However, since the macro-instruction DFMP will be replaced by a macro-expansion consisting of 12 instructions (see below), the TMI and TIX instructions in this sequence would both cause transfers to some "unknown" instruction in the macro-expansion.

Similarly, the sequence

```
            SCD        * 1,2
            TXL        NAME,4,**
```

would result in an error since the *1 indicates an instruction in the macro-expansion of the SCD instead of the TXL instruction as intended.

When assembling in the 7094 or 7094 II mode, the macro-operations listed in this section are automatically purged.

Group 1. PCA and PCD

For PCA, take w = A

For PCD, take w = D

The expansion is then

```
PCw          Y,T
                         PXw     Y,T
                         PwC     ,T
                         PXw     ,T
                         PwC     ,T
```

Group 2. SCA and SCD

For SCA, take w = A.

For SCD, take w = D.

The expansion is then

```
SCw          Y,T
                         SXA     *+1,T
                         AXC     **,T
                         SXw     Y,T
                         LXA     *-2,T
```

Group 3. DFAD, DFSB, DFAM, and DESM

For DFAD, take op = AD.

For DFSB, take op = SB.

For DFAM, take op = AM.

For DFSM, take op = SM.

In this and the following groups, the expansion below is also used:

```
(SAVE        Y,T
                         NOP     Y,T
                         STO     E.1
                         CLA*    *-2
                         STA     *+2
                         STT     *+1
                         PXA     ,0
                         SUB     *-1
                         SXA     CRS,4
                         PAC     0,4
                         CLA     E.1
```

There are four forms for these expansions:

```
DFop         Y,T
                         STQ     E.1
                         Fop     Y,T
                         STO     E.2
                         XCA
                         FAD     E.1
                         Fop     Y+1,T
                         FAD     E.2
DFop         **,T
                         NOP     ,T
                         STQ     E.1
                         Fop*    *-2
                         STO     E.2
                         TXI     *+1,T,-1
                         XCA
                         FAD     E.1
                         Fop*    *-7
                         FAD     E.2
                         TXI     *+1,T,1
DFop         **
or DFop      **,0
                         AXT     ,0
                         SXA     CRS,4
                         LAC     *-2,4
                         DFop    0,4
             CRS         AXT     ,4
DFop*        Y,T
                         (SAVE   Y,T
                         CLA     E.1
                         DFop    0,4
             CRS         AXT     ,4
```

Group 4. DLD and DST

For DLD, take op = LD, opa = CLA, and opb = LDQ.

For DST, take op = ST, opa = STO, and opb = STQ.

There are four forms for these expansions:

```
Dop          Y,T
                         opa     Y,T
                         opb     Y+1,T
Dop          **.T
                         opa     ,T
                         TXI     *+1,T,-1
                         opb*    *-2
                         TXI     *+1,T,1
Dop          **
or Dop       **,0
                         opa     0
                         SXA     *+3,4
                         LAC     *-2,4
                         opb     1,4
                         AXT     ,4
Dop*         Y,T
                         (SAVE   Y,T
                         IFT     /opa/=/STO/
                         CLA     E.1
                         opa     0,4
                         opb     1,4
             CRS         AXT     **,4
```

Group 5. DFMP

There are four forms for this expansion:

```
DFMP         Y,T
                         STO     E.1
                         FMP     Y,T
                         STO     E.2
                         LDQ     Y,T
                         FMP     E.1
                         STQ     E.3
                         STO     E.4
                         LDQ     Y+1,T
                         FMP     E.1
                         FAD     E.2
                         FAD     E.3
                         FAD     E.4
DFMP         **,T
                         NOP     **,T
                         STO     E.1
                         FMP*    *-2
                         STO      E.2
                         LDQ*     *-4
                         FMP      E.1
                         STQ      E.3
                         STO      E.4
                         TXI      *+1,T,-1
                         LDQ*     *-9
                         TXI      *+1,T,1
                         FMP      E.1
                         FAD      E.2
                         FAD      E.3
                         FAD      E.4
DFMP        **
or DFMP     **,0
                         AXT      **,0
                         SXA      CRS
                         LAC      *-2,4
                         DFMP     0,4
            CRS          AXT      **,4
DFMP*       Y,T
                         (SAVE    Y,T
                         CLA      E.1
                         DFMP     0,4
            CRS          AXT      **,4
```

Group 6. DFDP and DFDH
For DFDP, take w = P.
For DFDH, take w = H.

There are four forms for these expansions:

```
DFDw        Y,T
                         STQ      E.1
                         FDw      Y,T
                         STO      E.2
                         STQ      E.3
                         FMP      Y+1,T
                         CHS
                         FAD      E.2
                         FAD      E.1
                         FDw      Y,T
                         XCA
                         FAD      E.3
DFDw        **,T
                         NOP      ,T
                         STQ      E.1
                         FDw*     *-2
                         STO      E.2
                         STQ      E.3
                         TXI      *+1,T,-1
                         FMP*     *-6
                         CHS
                         FAD      E.2
                         FAD      E.1
                         TXI      *+1,T,1
                         FDw*     *-11
                         XCA
                         FAD      E.3
DFDw        **
or DFDw     **,0
                         AXT      **,0
                         SXA      CRS,4
                         LAC      *-2,4
                         DFDw     0,4
            CRS          AXT      **,4
DFDw*       Y,T
                         (SAVE    Y,T
                         CLA      E.1
                         DFDw     0,4
            CRS          AXT      **,4
```

Appendix C: Operation Code Formats

The operation code formats to be used with the OPD and OPVFD pseudo-operations are given in this appendix.

Operations

Entries are made in the Combined Operations Table for all OPD and OPVFD pseudo-operations, since the lookup process is the same as for any other symbol. To specify machine operations using OPVFD, the general form of this entry is

6/A,5/0,1/IND,2/ADD,2/TAG,2/DEC,18/V

where each group of bits in the instruction word is specified by an octal number. The same general form is used for OPD except that the 36-bit word is specified as a whole by a 12-digit octal number that will result in the same bit structure.

In this format, V varies with adjective code A (described below). The fields ADD, TAG, and DEC refer to address, tag, and decrement, respectively. The following code is used:

0	Field required
1	Field permissible
2	Field unexpected but allowed
3	Field not permissible

A 1 for IND indicates that indirect addressing is permitted, and a 0 indicates that it is not permitted.

The seven bits specifying fields IND, ADD, TAG, and DEC are denoted by FR (Fields Required).

Pseudo-Operations

The general form of the entry for pseudo-operations in the Combined Operations Table is

06/A, 12/N, 18/0

where A is the adjective code and N defines a specific pseudo-operation under that adjective code.

The single exception is the macro call (adjective code 62). The format for this entry is

06/62, 12/C, 3/SC, 15/L

where C is the number of parameters, SC is symbol creation information, and L is the location of the internal prototype. Adjective 62 is not allowed with OPD and OPVFD pseudo-operations.

Adjective Codes

The following list of octal adjective codes gives the type of operation to which each applies.

CODE (OCTAL)	OPERATION TYPE
40	A
41	Prefix or Modified Type B
42	Input/Output Command
43	B
44	C
45	D

CODE (OCTAL)	OPERATION TYPE
46	E
47	Select
50	Disk and Drum Channel Commands (4 fields)
51	Disk and Drum Channel Commands
52	Boolean Variable
53	Disk File and Drum File Orders
54	Unexpanded 7094 Instructions
55	Hypertape Orders
*56	Special Internal Code
*57	Special Internal Code

CODE (OCTAL)	PSEUDO-OPERATION TYPE
60	Macro Definition
61	Macro Related
*62	Macro Call
63	Location
64	Storage Allocation
65	Decimal Symbol Definition
66	Boolean Symbol Definition
67	Operation Defining
70	Dup and Skipping
71	Data Generating
72	Nongenerative
73	Absolute Assembly
*74	Commentary
75	Miscellaneous
76	Special System
77	List Control and Debug

*This adjective code is not usable with OPD and OPVFD pseudo operations.

TYPE A INSTRUCTIONS (40)

The entry is

O6/40,O5/0,O7/FR,O6/0,O12/OPCODE

where OPCODE is an octal machine code written with the prefix in the first digit. For example, OPCODE for the instruction TXI would be 1000.

PREFIX OPERATIONS (41)

This entry is

O6/41,O5/0,O7/FR,O6/0,O12/OPCODE

where OPCODE is written with the prefix in the first digit. For example, OPCODE for the instruction PON would be 1000.

MODIFIED TYPE B INSTRUCTIONS (41)

The entry is

O6/41,O5/0,O7/FR,O3/0,O3/D,O12/OPCODE

where OPCODE is written with the prefix in the first digit and D is a six or seven that is part of the machine code. For example, OPCODE for the 7040/7044 instruction MSM (Make Storage Sign Minus) would be 5623, and D would be 6. (The pseudo-operations in the form shown above can be used to assemble 7040/7044 sign position handling instructions. See Appendix F.)

INPUT/OUTPUT COMMANDS (42)

The entry is

O6/42,O5/0,O7/FR,O3/N,O3/0,O12/OPCODE

where OPCODE is written with the prefix in the first digit. For example, OPCODE for the instruction TCH would be 1000. If the instruction is a nontransmitting command, N = 2.

TYPE B INSTRUCTIONS (43)

The entry is

O6/43,O5/0,O7/FR,O6/0,O12/OPCODE

TYPE C INSTRUCTIONS (44)

The entry is

O6/44,O5/0,O7/FR,O6/0,O12/OPCODE

TYPE D INSTRUCTIONS (45)

The entry is

O6/45,O5/0,O7/FR,O6/0,O12/OPCODE

TYPE E INSTRUCTIONS (46)

The usual format is

O6/46,O5/0,O7/FR,O3/S,O15/EA

where S is the sign of the operation:
If S = 0, OPCODE would be +0760.
If S = 1, OPCODE would be −0760.
EA is the actual extended address of the instruction.

SELECT INSTRUCTIONS (47)

The entry is

O6/47,O5/0,O7/FR,O3/0,O3/E,O6/C,O6/OPCODE

OPCODE is the Select type, as follows:

0 = Read
1 = Write
2 = Set Density High
3 = Set Density Low
4 = Rewind
5 = Rewind Unload
6 = Backspace Record
7 = Backspace File
10 = Write End of File

C is the channel number of Select, starting at 1 for Channel A.

E is the equipment code and has the following significance:

0 = Decimal Tape
1 = Binary Tape; or either Binary or Decimal Tape
2 = Card Reader
3 = Punch
4 = Decimal Printer
5 = Binary Printer

See "Select Type" operations for specific address field requirements.

DISK AND DRUM CHANNEL COMMANDS (50)

The entry is

O6/50,O5/0,O7/FR,O6/0,O12/OPCODE

DISK AND DRUM CHANNEL COMMANDS (51)

The entry is

O6/51,O5/0,O7/FR,O3/N,O3/0,O12/OPCODE

where N = 2 if a 1 in bit position 19 is part of the operation code.

BOOLEAN VARIABLE (52)

The entry is

O6/52,O5/0,O7/FR,O6/0,O12/OPCODE

where the high-order bit of OPCODE is always ON.

DISK FILE AND DRUM FILE ORDERS (53)

The format is

O6/53,O6/0,O2/ACC,O2/TRK,O2/REC,
O6/0,O12/ORCODE

ORCODE is the order, written in external BCD notation. For example, DREL with an order code of 04 would be written 1204.

The fields ACC, TRK, and REC refer to the access module, track, and record, respectively. Encoding is:

1 Field permissible

UNEXPANDED 7094 INSTRUCTIONS (54)

The entry is

O6/54,O5/0,O7/FR,O6/0,O12/OPCODE

HYPERTAPE ORDERS (55)

The entry is

O6/55,O6/0,O2/ADD,O10/0,O12/OPCODE

The following is a list of pseudo-operations corresponding to specific A's and N's.

A	N	PSEUDO-OPERATION
60	0	MACRO
61	0	IFT
	1	IFF
	2	IRP
	3	SET
	4	ORGCRS
	5	NOCRS
	6	ENDM
63	0	USE
	1	BEGIN
	2	ORG
	3	LOC
64	0	BSS
	1	BES
	2	COMMON
	3	EVEN
	4	LORG
	5	LDIR
	6	LITORG
65	0	EQU (and SYN)
	1	MAX
	2	MIN
66	0	BOOL
	1	LBOOL
	2	RBOOL
67	0	OPD
	1	OPVFD
	2	OPSYN
70	0	DUP
	1	GOTO
71	0	OCT
	1	DEC
	2	BCI
	3	LIT
	4	VFD
72	0	QUAL
	1	ENDQ
	2	CONTRL
	3	FILE
	4	ENTRY
	5	LABEL
73	0	ABS
	1	FUL
	2	TCD
	3	PUNCH
	4	UNPNCH
75	0	ETC
	1	REM
	2	NULL
	3	END
	4	PURGE
76	0	CALL
	1	SAVE
	2	SAVEN
77	0	UNLIST
	1	LIST
	2	TITLE
	3	DETAIL
	4	EJECT
	5	SPACE
	6	LBL
	7	PCC
	8	INDEX
	9	PMC
	10	TTL
	11	PCG
	12	KEEP

Appendix D: IBMAP-FAP Incompatibilities

This appendix lists the incompatibilities that will occur when assembling a FAP or IBSFAP program using IBMAP.

1. All FAP machine operations and extended machine operations will assemble properly in MAP.

2. All FAP pseudo-operations pertaining to the update facility have no counterpart in MAP. They are:

DELETE	NUMBER	UMC
ENDFIL	REWIND	UNLOAD
ENDUP	SKIPTO	UPDATE
IGNORE	SKPFIL	

3. The following FAP pseudo-operations have no counterpart in MAP. (Since MAP treats undefined operations as remarks, some of these operations do not affect assembly.)

IFEOF	TAPENO
PRINT	704
SST	9LP

4. The following FAP pseudo-operations must be replaced by the indicated MAP equivalent:

FAP	MAP
HEAD,HED	QUAL,ENDQ
BCD	BCI
MOP	MACRO
MAC	Standard macro-instruction
END (of macro)	ENDM
RMT	USE and USE PREVIOUS

(Note that QUAL permits nesting of qualifiers, whereas HEAD does not.)

The following is an example of a program segment coded first in FAP and then in MAP.

FAP

```
                RMT
                BSS       10
                RMT
                .
                .
                .
ALPHA           RMT       *
                EXTERN
                SKP
                SPC
                TSX       $SUB,4
```

MAP

```
                USE       RMT
                BSS       10
                USE       PREVIOUS
                .
                .
                .
                BEGIN     RMT, ALPHA
                Leave
                symbols
                undefined
                EJECT
                SPACE
                TSX       SUB,4 (remove all $ signs that
                                 specify external names)
```

5. The following pseudo-operations have identical names in FAP and MAP but differ in context or meaning:

IFF

The meaning of the mnemonic and, therefore, the contents of the variable field, differ.

COMMON

COMMON counter increments forward in MAP.

DUP

In MAP, the S-value of symbolic instruction and iteration counts is used. Therefore, a FAP sequence such as

```
N               EQU       5
                DUP       1,N
```

must be changed in MAP, to

```
N               SET       5
                DUP       1,N
```

Also, in MAP, a symbol placed in the name field of a card within the range of a DUP is duplicated along with the rest of the card.

EQU,SYN

In MAP, these apply to symbol definitions only and cannot be used where an S-value is required; see DUP above.

OPD,OPVFD

The variable field should correspond to the MAP dictionary entry format (see Appendix C).

MACRO

In MAP, this is used as

```
NAME        MACRO     A,B,C,...
```

and may not be used as

```
            MACRO
            NAME      A,B,C,...
```

LOC

In MAP, the expression

```
            LOC       blank
```

is meaningless. The effect of a LOC is terminated with the ORG pseudo-operation.

NULL

In MAP, a symbol in the name field of the card will be given the value of the current location counter.

CALL

In MAP, the arguments must be enclosed in parentheses. Also, a different calling sequence is generated.

SET

In MAP, the S-value of symbols in the variable field is used.

6. The following FAP pseudo-operations have their equivalent option specified on the $IBMAP card:

REF
7090
COUNT
SST

7. In MAP, the NULL pseudo-operation rather than EQU * should be used for symbol definition, because of the limited size of the Pseudo-Operation Dictionary.

8. The following FAP pseudo-operations will assemble properly in MAP:

ABS	FULL	ORGCRS
BCI	INDEX	PCC
BES	LBL	PMC
BOOL	LIST	REM
BSS	MAX	SPACE
DEC	MIN	TCD
DETAIL	NOCRS	TITLE
EJECT	OCT	UNLIST
ENTRY	OPSYN	TTL
ETC	ORG	VFD

9. In MAP, virtual entries in the Control Dictionary correspond to the transfer vector of FAP except that IBLDR provides direct rather than indirect references.

10. In MAP, normal arithmetic truncates to 15 bits in the address field, 3 in the tag, and as specified in the decrement. VFD symbolic arithmetic truncates to a maximum of 20 bits. Boolean arithmetic truncates to 18 bits.

11. Literals are placed in the literal pool in the order in which they appear in a program; they are not arranged numerically.

Appendix E: The MAP BCD Character Code

The MAP BCD character code is shown in octal form in in the following table with the corresponding IBM punched card code.

CHARACTER	BCD CODE (OCTAL)	CARD CODE
(blank)	60	(blank)
0	00	0
1	01	1
2	02	2
3	03	3
4	04	4
5	05	5
6	06	6
7	07	7
8	10	8
9	11	9
A	21	12-1
B	22	12-2
C	23	12-3
D	24	12-4
E	25	12-5
F	26	12-6
G	27	12-7
H	30	12-8
I	31	12-9
J	41	11-1
K	42	11-2
L	43	11-3
M	44	11-4
N	45	11-5
O	46	11-6
P	47	11-7
Q	50	11-8
R	51	11-9
S	62	0-2
T	63	0-3
U	64	0-4
V	65	0-5
W	66	0-6
X	67	0-7
Y	70	0-8
Z	71	0-9
+ (plus)	20	12
− (minus)	40	11
/ (slash)	61	0-1
= (equals)	13	8-3
' (apostrophe)	14	8-4
. (period)	33	12-8-3
) (right parenthesis)	34	12-8-4
$ (dollar sign)	53	11-8-3
* (asterisk)	54	11-8-4
, (comma)	73	0-8-3
((left parenthesis)	74	0-8-4

Appendix F: Assembly of 7040/7044 Programs on a 7090/7094

A 7040/7044 MAP Language source deck can be assembled and executed on the 7090/7094, but the resultant binary cards are not compatible with the 7040/7044 and cannot be executed on the 7040/7044. Most 7040/7044 instructions are identical to those on the 7090/7094, so that no changes or additions must be made to ensure their proper assembly. Some 7040/7044 instructions, however, must be defined using an OPVFD or OPD pseudo-operation, and others require definition as macro-instructions.

The 7040/7044 instructions which are compatible with those on the 7090/7094 are listed in the "Systems Compatibility" section of the publication *IBM 7040/7044 Principles of Operation,* Form A22-6649. The 7040/7044 double-precision floating-point instructions will be assembled directly or expanded as macro-instructions, depending on whether M94 or M90 is specified on the $IBMAP card.

The following 7040/7044 instructions must be defined with an OPD or OPVFD pseudo-operation:

1. An instruction (except an STR) with the 12-bit operation code −1xxx and no part of the operation code in the address field.
2. The Sign Position Handling instructions.
3. The Character Handling operations.
4. The Data Transmission instructions.
5. The Memory Protect instructions.
6. The Direct Data Connection instructions.

For example, the variable field of the OPVFD or OPD pseudo-operation used to define the 7040/7044 TRP (Transfer and Restore Parity and Traps) instruction would be:

```
O6/43,5/0,O7/106,6/0,O12/5165
```

The following 7040/7044 instructions must be defined by a macro-operation:

1. Input/Output instructions (except RDS and WRS).
2. Instructions which have part of the operation code in the low-order part of the address field and have a 12-bit operation code of −1xxx.
3. Instructions requiring a one in bit position 14. The following coding illustrates the use of a macro-operation in defining the CTR (Control Select) instruction:

```
CTR     MACRO     A,T,I
        VFD       O15/57661,3/I,3/T,O15/A
        ENDM      CTR,NOCRS
```

Where A is the address field, T is the tag field, and I is the interface.

It is the responsibility of the programmer to ensure that only 7040/7044 instructions are used, since any 7090/7094 instructions in the program will be assembled and will not be flagged. The following 7040/7044 pseudo-operations differ to some extent from those in 7090/7094 MAP: IFF/IFT, OPD, CALL, SAVE, RETURN, FILE, LABEL, and TTL. Also, there is no EXTERN pseudo-operation in 7090/7094 MAP.

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